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NO_x Waiver Decision of the Administrator and Revised Motor Vehicle Exhaust Emission Standards for Oxides of Nitrogen (NO_x) for 1981 and 1982 Model Year Light-Duty Vehicles

ENVIRONMENTAL PROTECTION AGENCY

[FRL 1381-4]

NO_x Waiver Decision; Decision of the Administrator

I. Introduction

Section 202(b)(1)(B) of the Clean Air Act, as amended ("Act"), establishes the standards applicable to emissions of oxides of nitrogen (NO_x) from light-duty vehicles and engines manufactured during and after model year 1977.[1] This section requires the Administrator of the Environmental Protection Agency (EPA) to promulgate regulations containing standards which provide that NO_x emissions may not exceed 2.0 grams per vehicle mile (gpm) for model years 1977 through 1980, and may not exceed 1.0 gpm for 1981 and later model years.

Section 202(b)(6)(B) of the Act authorizes the Administrator to delay implementation of the 1.0 gpm NO_x standard by waiving it under certain conditions to permit the use of diesel engine technology.[2] Section 202(b)(6)(B) of the Act provides that, upon the petition of a manufacturer, the Administrator may waive the 1.0 gpm NO_x standard to a level not to exceed 1.5 gpm, for any class or category of diesel-powered light-duty vehicles and engines manufactured during the four model year period beginning with model year 1981. In order to obtain a waiver, the manufacturer must show that it is necessary to permit the use of diesel engine technology in the class or category of vehicles or engines for which a waiver is requested. Moreover, the Administrator must determine:

(i) That such waiver will not endanger public health,

(ii) That such waiver will result in significant fuel savings at least equal to the fuel economy standard applicable in each year under the Energy Policy and Conservation Act ("EPCA"), and

(iii) That the technology has a potential for long-term air quality benefit and has the potential to meet or exceed the average fuel economy standard applicable under EPCA at the expiration of the waiver. The major consideration in providing for waiver of the NO_x standard for diesel-powered vehicles was the potential fuel economy benefits of diesel technology.[3] Because control of NO_x emissions from diesel engines appeared to be a more difficult technical problem than NOx control in gasoline-powered vehicles, Congress did not want to preclude use of this fuel-efficient technology in light-duty vehicles due to the stringent 1.0 gpm NO_x standard. However, it is clear that Congress did not intend that consideration of fuel savings override consideration of public health and air quality.[4] While the NO_x waiver provision is intended to further the development of diesel technology, it is not intended as an unqualified endorsement of that technology. Therefore, the NO_x waiver provision, according to Senator Muskie, "is not intended to provide a loophole in the statutory standards, but only to provide an opportunity for technology development which may lead to greatly improved emissions performance in the next decade."[5]

On July 14, 1978, guidelines for the submission of applications under this waiver provision were published in the **Federal Register.**[6] The guidelines follow the language of the Act in placing an affirmative burden on the manufacturer to supply information sufficient to satisfy independently each of the waiver criteria set forth above for each engine family for which a waiver was requested,[7] and in stressing that

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[1] 42 U.S.C. 7521(b)(1)(B) (Supp. I 1977). Congress first set statutory emissions standards for NO_x emissions from light duty vehicles and engines in the 1970 Amendments to the Act. Clean Air Act Amendments of 1970, Pub. L. No. 91-604, 81 Stat. 499 (1970). Section 202(b)(1)(B) of that version of the Act required that NO_x emissions standards for 1976 and later model year vehicles represent a 90 percent reduction from the average emissions of NO_x actually measured from light-duty vehicles manufactured during model year 1971 which were not subject to any Federal or State NO_x emission requirements. Section 202(b)(5)(B) permitted the Administraor to grant a one year suspension of this standard if the manufacturers could meet the statutory criteria. *See,* Clean Air Act, as amended 1970, § 202(b)(5)(B). These criteria also applied to suspension of carbon monoxide and hydrocarbon emission standards.

In 1974 Congress amended the Act and established a 2.0 gpm NO_x standard for light-duty vehicles and engines manufactured during model year 1977, and postponed the effective date of the "90 percent reduction standard" until model year 1978. Energy Supply and Environmental Coordination Act of 1974, Pub. L. No. 93-319 (1974). Although suspension provisions were retained from the 1970 version of the Act for statutory carbon monoxide and hydrocarbon emissions standards, the NO_x suspension provision was not retained by Congress. Compare the Clean Air Act, as amended, 1970, § 202(b)(5), with the Clean Air Act, as amended, June, 1974, § 202(b)(5).

In 1977, Congress again amended the Act, extending the 2.0 gpm NO_x standard for light-duty vehicles and engines through model year 1980. For model years 1981 and after, the 90 percent reduction standard of 0.4 gpm was established as a research objective, and a standard of 1.0 gpm was established, based upon the manufacturers' testimony on their ability to develop the requisite technology to meet 1.0 gpm.

[2] 42 U.S.C. 7521(b)(6)(B) (Supp. I 1977). Although the House and Senate versions of the waiver provision referred generally to "innovative technology", it is evident from the early legislative debates that the waiver was intended to further the development of diesel technology in particular because of its potential for fuel economy benefits and improved emissions. *See, e.g.,* 123 Cong. Rec. 4945 (daily ed. May 24, 1977) (remarks of Congressman Rogers); 123 Cong. Rec. 5106-7, 5117, 5119-20 (daily ed. May 26, 1977) (remarks of Congressman Dingell, Preyer and Broyhill); 123 Cong. Rec. 9294 (daily ed. June 9, 1977) (remarks of Senator Baker). The Conference Committee separated the current waiver provision dealing solely with diesels from the general provision for innovative technology, now section 202(b)(6)(A) of the Act, 42 U.S.C. 7521(b)(6)(A) (Supp. I 1977).

[3] The waiver for innovative technology contained in the Dingell-Broyhill amendment adopted by the House, which provided the basis for the statutory waiver, specified that there should be the potential for "substantial energy savings * * * as compared to conventional power trains incorporating spark ignited, gasoline, internal combustion engines." H.R. 6161, 95th Cong., 1st Sess. § 203 (1977); *see also* 123 Cong. Rec. 4958, 5106 (daily ed. May 24, 1977) (remarks of Congressman Dingell). The Senate version, originating in the amendment introduced by Senator Baker, would have allowed waivers for innovative engines systems with "fuel economy at least equivalent to the fuel economy standard applicable in such model year under the Energy Policy and Conservation Act". 123 Cong. Rec. 9299 (daily ed. June 9, 1977); H.R. 6161 (Senate version), 95th Cong. 1st Sess. § 203 at p. 326 (1977). This language was substantially incorporated in the final waiver provision as the second waiver criterion under § 202(b)(6)(B), which requires a finding of "significant fuel savings at least equal to the fuel economy standard applicable in each year under the Energy Policy and Conservation Act * * *" *See also* 123 Cong. Rec. 9294 (daily ed. June 9, 1979) (remarks of Senator Baker).

[4] H.R. Rep. No. 294, 95th Cong., 1st Sess. 250-51 (1977); 123 Cong. Rec. 5120 (daily ed. May 20, 1977) (remarks of Congressman Broyhill); 123 Cong. Rec. 13703 (daily ed. Aug. 4, 1977) (remarks of Senator Muskie).

[5] 123 Cong. Rec. 13703 (daily ed. August 4, 1977).

[6] 43 FR 30341 (July 14, 1978).

[7] GM has argued that the diesel engine waiver was intended to apply to all light-duty diesel vehicles. General Motors Application, Supplement, dated July 18, 1979 ("GM Supp.") 1-4.

I have the statutory authority to grant a waiver for individual engine families. Section 202(b)(6)(B) of the Act expressly provides: the Administrator * * * may waive the (NO_x) standard * * * *for any class or category of light-duty vehicles and engines* manufactured * * * if the manufacturer can show that such waiver is necessary to permit the use of diesel engine technology *in such class or category of vehicles or engines.* (Emphasis added.)

In order to interpret section 202(b)(6)(B) as limiting my authority to granting a waiver to all or no diesel engine families, the language emphasized above would have to be read completely out of the statute. I refuse to so read the statute. The language of section 202(b)(6)(B) indicates that Congress clearly contemplated waivers for classes or categories of diesels, not all diesels, and I have interpreted "class or category" to be synonymous with "engine family". 43 FR 30341, 30342 (July 6, 1978). The term "engine family" is defined in 40 CFR 86.077-2 (1977) as "the basic classification unit of a manufacturer's product line used for the purpose of test fleet selection as determined in accordance with" 40 CFR 86.077-24. The latter section lists the characteristics and specifications for which a group of engines must be identical in order to be considered an "engine family" and therefore a "class or category."

The legislative history supports this interpretation. In presenting the Conference Report to the Senate, Senator Muskie stated in regard to the diesel NO_x waiver provision:

This waiver is to be applied on a class or category basis, rather than across the board. It is only available for a *particular* class or category of light

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although the waiver might be requested for the four model year period beginning with the 1981 model year up to a NO_x level of 1.5 gpm, the waiver would be granted for a shorter period of time and to an intermediate NO_x level between 1.0 and 1.5 gpm if the manufacturer could not establish the necessity for a waiver to the maximum NO_x level for the full, four-year period.[8]

On May 2, 1979, General Motors Corporation ("GM") filed with the Administrator an application for waiver of the NO_x standard to a level of 1.5 gpm for all of its light-duty diesels to be produced in model years 1981 through 1984. Applications were received subsequently from Daimler-Benz ("D–B"), Volkswagen ("VW"), Peugeot and Volvo.[9]

A **Federal Register** notice published on June 6, 1979, announced receipt of these applications and invited public participation at hearings on the waiver requests,[10] which were held on June 18–21, 1979, in Washington, D.C.

II. Summary of Decision

I have decided to grant NO_x waivers to the following engine families for model years 1981 and 1982:

Manufacturer	Engine family	Model years	Interim standard (gpm)
Daimler-Benz	OM 616 W 123 D 24 (2.4 liter) [11]	1981	1.5
		1982	1.25
	OM 617 W 123 D 30 (3.0 liter naturally aspirated) [12]	1981, 1982	1.5
	OM 617 AW 116 D 30A (3.0 liter turbocharged) [13]	1981, 1982	1.5
General Motors Corp.	5.7 liter	1981, 1982	1.5
Volvo	6 cylinder, 2.4 liter naturally aspirated	1981, 1982	1.5

[11] This engine family includes only model 240D, and will be referred to as "D–B's 2.4 liter engine family".
[12] This engine family includes only models 300D, 300 TD and 300 CD, and will be referred to as "D–B's 3.0 liter naturally aspirated engine family".
[13] This engine family includes only model 300SD, and will be referred to as "D–B's 3.0 liter turbocharged engine family".

All other applications covering engine families for 1981 and 1982 model years and all applications for model years 1983 and 1984 vehicles are denied on the basis that insufficient information was submitted to show the need for a NO_x waiver to permit use of diesel engine technology in those engine families.

The need for waiver for model years 1981 and 1982 has been shown for GM's 5.7 liter, D–B's 3.0 liter turbocharged and Volvo's 2.4 liter naturally aspirated engine families. Waivers are necessary for model year 1981 because the data submitted by the applicants for these engine families and analyzed by EPA in accordance with the methodology utilized to assess technological feasibility has established that these engine families cannot meet the 1.0 gpm NO_x standard in 1981. A waiver for these engine families is necessary for model year 1982 to provide for production of these families incorporating advanced emission controls in California in 1982 before incorporation of such controls into the 49-state fleet in 1983. This phase-in is necessary in order to protect against the risks of using advanced NO_x controls in the 49-state fleet without smaller scale production experience. The California experience should permit the manufacture of these engine families to meet the statutory standards nationwide in model year 1983 with a minimum of in-use and production problems.

The need for a waiver has been shown for D–B's 2.4 liter and 3.0 liter naturally aspirated engine families despite the presence of control technology that might permit these engine families to meet the statutory standards for 1981. This technology has an uncertain effect on the durability of the engine (i.e., engine wear) requiring further development and phased-in production. Therefore, these engine families need waivers for model years 1981 and 1982 in order to permit their production nationwide for model year 1983 to meet statutory standards with properly minimized in-use, durability and production problems.

Applicants have failed to provide sufficient emissions data upon which I can make a determination for all other engine families. It is impossible to determine the capabilities of these engine families with or without application of available control technologies. Therefore, I must deny the applications for the remaining, "no-data" families. Of course, the manufacturers may reapply for waivers for these engine families when they can provide sufficient emission data to enable me to make the necessary determinations.

I have determined that waiving the 1.0 gpm NO_x standard for two model years for the five engine families listed above would be more protective of the public health than if I denied the waivers. As discussed more fully below, my primary concern in considering the health impact of a waiver involves emissions of diesel particulates. Existing evidence suggests that exposure to diesel particulate emissions may pose a serious health risk, of cancer, requiring me to take a cautious approach in any action that may increase those emissions. It appears that the only technology generally available to the manufacturers in 1981 which might have the possibility of achieving NO_x reductions to the statutory level of 1.0 gpm—exhaust gas recirculation (EGR)—tends to increase significantly emissions of diesel particulates. I have determined that the manufacturers have shown that the waivers are necessary for the five engine families listed above because the

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duty vehicle * * *. Thus, for example, it may develop that the diesel waiver is unnecessary for demonstration of the diesel technology in the lower weight classes. (123 Cong. Rec. 13703 (daily ed. Aug. 4, 1977).)

Clearly, a section 202(b)(6)(B) waiver need not cover all diesel engines and vehicles.

[8] GM argues that the diesel engine waiver was intended to last for precisely four years. GM Supp., 1–4.

I have the authority to grant a waiver for less than four years. Section 202(b)(6)(B) provides: the Administrator * * * may waive the (1.0 gpm NO_x) standard * * * for any class or category of light-duty vehicles and engines manufacturered * * * *during the four model year period beginning with the model year 1981* if the manufacturer can show the waiver is necessary * * * (Emphasis added.)

The statute, on its face, does not require a four year "all or nothing" waiver. Moreover, that portion of the House bill requiring a waiver "for a period of not less than four model years" was dropped in Conference. Section 203(b)(6)(C) of H.R. 6161, printed at 123 Cong. Rec. 5100 (daily ed. May 26, 1977). An identical provision sought to be included in the Senate bill was expressly rejected by the Senate. Riegle-Griffin Amendment, Unprinted Senate Amendment No. 380, 123 Cong. Rec. 59278 (daily ed. June 9, 1977). Thus, the legislative history supports my Guidelines which stress that a NO_x waiver will be granted for a period shorter than four years if the subject diesel vehicles can meet the statutory standards prior to the 1985 model year. 43 FR 30342 (July 6, 1978). Further it is unreasonable to attribute an intent on the part of Congress to grant a waiver of the statutory NO_x standard which Congress itself established as protective of the public health, for a period greater than that which the manufacturer has shown is necessary to develop diesel technology.

[9] This decision uses the following abbreviated citations:

D-B App.—Statement of Daimler-Benz AG in Support of Request for a NO_x Waiver, dated June, 1979.

GM App.—General Motors Application for Waiver of the 1981–1984 NO_x Emission Standard for Light-Duty Diesel Engines, dated May 1, 1979.

P App.—Automobiles Peugeot Application for Waiver of the 1981–1984 NO_x Emission Standard, dated May 21, 1979.

V App.—AB Volvo Application for Waiver of Oxides of Nitrogen Emissions Standards for Light-Duty Diesel Engines for 1981 to 1984, dated June, 1979.

VW App.—Application for Waiver of the 1981–1984 NO_x Emission Standards for Light-Duty Engines submitted by Volkswagen AG, dated May, 1979.

The hearing transcripts are cited to by the day and the manufacturer testifying, e.g., "June 18 Tr. —— (D-B)."

[10] 44 FR 32470 (June 6, 1979).

record indicates that without the waivers the manufacturers probably cannot meet the NO_x standard. However, because of the range of uncertainty in the analyses used to predict vehicle emissions performance, there remains a possibility that, if I deny the waivers, the manufacturers may still be able to certify, produce and market these engine families to meet 1.0 gpm NO_x by using increased EGR. While the NO_x waiver provision authorizes me to deny waiver requests, it does not authorize me to deny applications for certification if the vehicles meet statutory standards.[14] Several manufacturers at the hearings indicated that marketing such diesel vehicles would result in significantly increased particulate emissions, increasing the risk to the public of exposure to possibly carcinogenic matter. Therefore, in making this waiver decision, I must weigh the risks of increased NO_x emissions if I grant the waiver against the risks of increased particulate emissions if I deny the waiver, but manufacturers are still able to produce diesel light-duty vehicles meeting the NO_x standard. Though increased NO_x emissions are certain to result from a waiver grant and significantly increased particulate emissions are far less certain to result from a waiver denial, the health risk to the public, if exposed to increased particulate levels, may be substantially more serious. Therefore, I think it preferable from a health standpoint to accept the risk of higher NO_x exposures and minimize the risk of greater exposure to diesel particulates. On this basis, I conclude that granting the waiver to the subject engine families will not endanger the public health and, in fact, will be more protective of the public health than waiver denial.

Each of the five engine families for which a waiver is granted will meet the fuel economy standards applicable under EPCA for model years 1981 and 1982 (22 and 24 mpg, respectively); and the diesel fleets of the three manufacturers receiving waivers (GM, D–B and Volvo) have the potential to meet, on a sales-weighted basis, the Corporate Average Fuel Economy (CAFE) standard applicable at the expiration of the waiver period in model year 1983 (26 mpg). Thus, the fuel economy criteria of section 202(b)(6)(B) are met for these engine families.

The diesel engine technology also has the potential for long-term air quality benefit. There is a substantial likelihood that each of the five engine families covered by a waiver will be capable of complying with the statutory emissions standards applicable at the expiration of the waiver period due to the additional lead time available to further develop necessary control technology.

III. Discussion

A. Assessing Need for Waivers

Section 202(b)(6)(B) of the Act expressly assigns to an applicant the burden of showing that the waiver is necessary to permit the use of diesel engine technology in a particular class or category of vehicles or engines. The major issue to be addreesed under this criterion is whether the applicant has shown that unless the waiver is granted the vehicle for which the waiver is sought will not be able to meet applicable statutory standards (i.e., 0.41 gpm HC, 3.4 gmp CO and 1.0 gpm NO_x), even with the addition of any device, equipment or aspect of diesel engine technology, presently available or available in the future.[15]

1. Applicants' Positions Summarized

As is the case with emission controls for other pollutants,[16] each automobile manufacturer has reached a state in its development of NO_x emission controls at which it has narrowed the range of strategies it comtemplates employing to meet the 1.0 gpm standard to, at most, a few alternative systems. Some of these systems are further along in development than others. To support the contention that effective control technology is not available, each waiver applicant has provided descriptions of the systems it has been considering in its efforts to meet the 1.0 gpm NO_x standard and the proposed standard for particulates.[17] Most of the applicants plan to utilize some type of EGR system to reduce NO_x emissions in diesel vehicles to 1.0 gpm.[18] The waiver applications in many cases lacked acceptable emission test data for specific engine families.[19] This paucity of data resulted in an inability to determine the technological capabilities of several engine families.[20]

a. GM

GM sought a NO_x waiver to 1.5 gpm for all of its light-duty diesel engine families for the maximum four-year period.[21] GM asserts that technology is not available to permit its engine families to meet the statutory 1.0 gpm NO_x and the 0.41 gpm hydrocarbon (HC) standards, the proposed 0.6 gpm particulate standard and minimum durability requirements.[22]

GM asserted that there is an inverse relationship between NO_x and particulate emissions because as the most effective emission controls are applied to reduce NO_x, particulates increase.[23] GM stated that the most promising approach to meeting 1.0 gpm NO_x is use of EGR.[24] GM asserted that increased use of EGR results in increased particulate emissions[25] and reduced durability, driveability, and fuel economy. GM asserted that the durability problem is due to high levels of carbon in the engine lubricating oil, these levels increasing with increased use of EGR, resulting in unacceptable wear rates on engine parts.[26] GM stated that although there is some hope of solving these problems, no practical solutions exist at this time and a four-year waiver is necessary to permit development of the technology.[27]

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[14] Although section 202(b)(6)(B) does not authorize me to prevent the marketing of diesels even if I deny waivers, section 202(a)(4), 42 U.S.C. 7521(a)(4), grants me the authority to deny requests for certificates of conformity if unregulated emissions would cause or contribute to an unreasonable risk to public health. The waiver grants do not affect this authority. See discussion in note 177 *infra*.

[15] Guidelines, 43 FR 30342 (July 14, 1978).

[16] *See e.g.*, 44 FR 53376, 53378 (Sept. 13, 1979). (range of emission control strategies for carbon monoxide found to be narrowed).

[17] EPA has proposed particulate standards for light-duty vehicles of 0.6 gpm for the 1981 model year and 0.2 gpm for the 1983 and later model years. 44 FR 6650 (Feb. 1, 1979).

[18] The basic theory behind diesel EGR is that substituting inert non-combustible gas for a portion of the air intake reduces the mass flow through the engine and provides an air/exhaust gas mixture for combustion which has a higher specific heat capacity resulting from the higher specific heat capacity of the exhaust gas substituted for air. This causes the combustion temperatures in the engine and the oxygen mass in the cylinders to be reduced, resulting in lower NO_x emissions. (*See, e.g.*, D–B App., II–27 to II–28.) Diesel EGR accomplishes this substitution of non-combustible gas for air by recirculating engine exhaust gas. (*Id.* at II–26.) A primary technological problem with applying EGR to the diesel engine is that EGR cannot be used in equal amounts throughout all engine operating conditions. *See, e.g., id.* at II–26; GM App, II–27 to II–28. Thus, a system must be designed capable of determining when and at what levels EGR may be most effectively applied and of controlling the application of EGR accordingly.

[19] EPA, Summary of Technological Capability, Appendix A (hereinafter "Appendix A") § II.

[20] Appendix A, § IV.

[21] GM App., I–4.

[22] *Id.*

[23] GM App., I–2 and II–26 to II–27.

[24] GM App. I–2, II–8, II–26 to II–27. GM also stated that the proposed standards are not likely to be met only by engine modifications. GM App., II–27.

[25] GM App. II–27 to II–30; GM Supp. 15. GM also indicated that particulates are an inherent by-product of the diesel process. GM App., II–37 to II–380.

[26] GM App., II–27 to II–30, GM Supp., 15; GM App., I–2 and II–13 to II–18. GM asserted the carbon level contamination does not appear to be strictly a function of the particulate level. GM App., II–14. GM is experimenting with using different materials in engine parts to withstand wear, and with filtration, centrifugal separation and electrostatic coagulation to filter out the excess carbon. *Id.* at II–15 to II–17.

[27] GM App., I–3 to I–5, I–9.

b. Daimler-Benz

D–B requested varying waivers of the 1.0 gpm NO_x standard, depending on the engine family, the diesel particulate standard applicable in 1983 and 1984, and the capabilities of an advanced EGR system to be certified for California and that system's response in actural use.[28] D–B stated that it knows of no existing technology which would achieve simutaneously the 1.0 gpm NO_x standard, the existing HC and CO standards and the proposed 0.6 gpm particulate standard.[29] Therefore, D–B sought waivers up to 1.5 gpm NO_x for all three of its 1981 model year engine families.[30] D–B stated that in order to achieve the 1.5 gpm NO_x standard, the 3.0 liter turbocharged and naturally aspirated engine families will use a simplified EGR system now being developed, and the 3.0 liter turbocharge and natually aspirated engine families will use a simplified EGR system now being developed, and the 2.4 liter engine family may possibly be certified without EGR.[31] The simplified EGR system will be used for the first time in California in model year 1980.[32]

D–B stated that it currently is experimenting with an advanced EGR system[33] which may achieve 1.0 gpm NO_x as well as the other emissions standards (including the proposed 0.6 gpm particulate standard) with acceptable durability and driveability, and that this system may be available for use in model year 1982.[34] Although D–B must certify its 1982 California diesel fleet at a NO_x emission level of at least 1.0 gpm while meeting the federal particulate standard, if promulgated, D–B does not want to utilize the advanced EGR system in 1982 for its 49-state diesel fleet without prior serial production and in-use experience.[35] D–B asserted that such experience in California is needed as a necessary phase-in to judge the success of the system in the field.[36] Therefore, to avoid jeopardizing its 49-state fleet in model year 1982, D–B requested waivers for model year 1982 up to 1.25 gpm NO_x for its 2.4 liter engine family and to 1.5 gpm NO_x for its 3.0 liter turbocharged and naturally aspirated engine families.[37]

D–B also requested "conditional" waivers for 1983 and 1984 of up to 1.25 for its 2.4 liter engine family and up to 1.5 for all other engine families.[38] The waivers would be granted but automatically rescinded upon satisfactory experience in California in 1982 and promulgation of a diesel particulate standard of 0.6 gpm for 1983 and 1984.[39]

c. Peugeot

Peugeot requested a waiver of the NO_x standard to a level of 1.5 gpm for its light-duty diesel vehicles in the 3500 pound class for model years 1981 through 1984.[40] Peugeot stated that there is no technology presently available to enable it to meet, in production, both 1.0 gpm NO_x and the proposed diesel particulate standards for model years 1981 through 1984.[41] Peugeot is relying totally on EGR systems to reduce NO_x emissions.[42] Peugeot stated that it may be able to meet a 1.0 gpm NO_x and a particulate standard of 1.0 gpm in California in 1982,[43] and that successful compliance in 1982 California production would result in Peugeot trying to market those diesels nationwide in model year 1983, if a 1.0 gpm particulate standard is applicable.[44] Peugeot stated that without a 1.0 gpm diesel particulate standard, a waiver also is necessary for 1983 and 1984.[45]

d. VW

VW requested a waiver of the 1.0 gpm NO_x standard for 1981 through 1984 for three classes of vehicles: Rabbit, Dasher and Audi 5000.[46] VW sought interim NO_x standards that decrease over time and that vary for each vehicle class.[47]

In proposing the interim standards, VW assumed that its proposed Diesel Average Particulate Standard (DAPS) would be promulgated as the final diesel particulate standard.[48] The DAPS would set an average particulate emission standard to be met by a manufacturer's entire diesel fleet for a particular model year; however, individual engine families would not be required to meet the DAPS.[49]

VW stated that the waiver is necessary to ensure its ability to meet a 1.0 gpm NO_x standard in 1985 for all of its diesel vehicles by providing the "in use" production experience required for effective research and development.[50] VW asserted that it plans to use injection timing improvements to meet the interim standards, and does not plan to use an EGR system for any of its engine families until 1985, and then only on vehicles over 2500 pounds.[51] To achieve the proposed interim standards, VW plans to rely on: (1) Limited retardation of injection timing in model years 1981 and 1982; (2) a load controlled injection pump [52] and improved injection time distribution and injectors in model year 1983; and (3) further reduction of production tolerances in injection pumps and other parts in model year 1984.[53] For 1985 model year vehicles over 2500 pounds, VW stated that it plans to use EGR, trap oxidizers and optimized fuel injection timing to compensate for increased emissions of particulates and HC which result from the added EGR.[54] For 1985 model year vehicles under 2500 pounds, VW stated that it hopes to meet applicable standards without EGR by refining the above-described systems to be used in model years 1981 through 1984.[55] VW asserted that it could not apply EGR to its small diesel engine while retaining adequate performance

[28] D–B App., I–17.

[29] *Id.* at I–3.

[30] *Id.* at I–2, I–18.

[31] *Id.* at II–17, I–18. A description of the simplified EGR system is at II–34 to II–35.

[32] D–B App., II–22.

[33] A description of the advanced EGR system is found at D–B App., I–35 to I–46.

[34] *Id.*

[35] *Id.*

[36] *Id.*; June 18, Tr, 60 (D–B).

[37] D–B App., I–2 to I–3, I–18 to I–19, and II–23 to II–24.

[38] *Id.* at I–20.

[39] *Id.* at I–20 and I–22. D–B stated that even if the California experience is unsatisfactory in 1982 and, thus the conditional waiver is not suspended for model year 1983, if the 1983 California experience is satisfactory (and the particulate standard remains 0.6 gpm) the conditional waiver would be suspended for model year 1984. *Id.* at II–25 to II–26. D–B indicated that it is working on advanced diesel technologies (utilizing water injection) which may reduce NO_x emissions to 0.4 gpm. *Id.* at II–57 to II–75.

[40] P App., 1.–6.

[41] P App., 1.–2.

[42] *Id.* at 2.–1 to 2.–3; June 20 Tr, 5–6, 8 (P).

[43] P App., 1.–2.

[44] *Id.*

[45] *Id.* at 1.–3.

[46] VW App., 1.–4.

[47] The proposed interim NO_x standards are as follows:

	Rabbit class vehicles	Dasher class vehicles	Audi 5000 class vehicles
Model years:			
1981	1.3	1.4	1.5
1982	1.3	1.4	1.5
1983	1.15	1.3	1.4
1984	1.0	1.15	1.2

VW App., 2.–4.

[48] VW App., 1.–6. VW stated that it is able to comply with a DAPS of 0.6 gpm for model years 1981 and 1982, 0.4 gpm for 1983 and 1984, and 0.3 gpm for 1984 and thereafter. *Id.*

[49] Thus, a manufacturer could meet a DAPS where one of the average particulate emissions from one of its engine families is above the DAPS while the emissions from all of its other engine families are far below the DAPS. Each diesel engine families would be required to meet a Diesel Individual Particulate Standard. VW App., 1.–6.

[50] VW App., 1.–7.

[51] *Id.* at 1.–6 to 1.–7.

[52] According to VW this will enable it to control the benefits of retarded timing much more efficiently. VW App., 1.–6.

[53] VW App., 1.–6. VW claims that reduction of production tolerances is necessary in order to limit the high variabilities in emission behavior of diesel cars.

[54] VW App., 1.–7.

[55] *Id.* at 1.–6 to 1.–7.

levels.[56] In 1981, VW stated that it plans to substitute a 1.6 liter engine for its 1.5 liter Rabbit and Dasher diesel engine to allow addition of automatic transmission and air conditioning.[57] The 1.6 liter engine has higher emissions than the 1.5 liter engine.[58]

d. Volvo

Volvo requested a waiver for the 1981 through 1984 model years to 1.5 gpm NO_x level for its six cylinder, 2.4 liter turbocharged and normally aspirated engines and for its five cylinder, 2.0 liter turbocharged engine.[59] The thrust of Volvo's argument is that Volvo has entered the United States diesel market only recently and lacks the ability to develop and apply technology to permit its diesel engine families to achieve the 1.0 gpm NO_x standard.[60] Volvo stated that it has purchased its diesel engines from VW since 1976 for use in European markets,[61] and does not own its own diesel engine development or manufacturing facilities.[62] Volvo also stated that it presently relies on other manufacturers for development of emission control technology—Bosch for injection systems and VW for engine modifications—and, thus, has inherent lead-time problems.[63]

Volvo does not currently market diesels in the United States but is attempting to certify diesel passenger cars for sale in the United States for model year 1980.[64] Volvo claimed that it is uncertain whether it will be able to certify its diesel engine families in model year 1981 even if it is granted a waiver if the proposed particulate standard of 0.6 gpm is ultimately promulgated.[65]

Volvo stated that it plans to meet the waiver standard of 1.5 gpm NO_x by improving injection systems and by possibly making engine modifications.[66] In order to meet the 1985 model year NO_x standard of 1.0 gpm, Volvo stated it is working on engine modifications, injection systems, high rate EGR systems, and particulate control systems.[67]

2. Decision Methodology

Appendix A to this consolidated decision contains an assessment of technology available to meet the 1.0 gpm NO_x standard for each diesel engine family in question. The assessment is derived from a review of the information contained in the waiver applications and other information contained in the public record.

In evaluating the availability of effective control technology, Appendix A assesses, where possible, the emissions performance of each diesel engine family as described in the waiver appplication and of each family after hypothetically factoring in one or more "Projected Technological Improvements" ("factors"). The factors have been applied for currently known improvements and hardware that may be implemented during the waiver period (such as advanced EGR systems, injection timing modifications, water injection, fuel additives, air pump addition and inertia weight reductions).[68]

Appendix A employs methodology which applies these few carefully selected, purposely conservative factors to emission test results supplied by waiver applicants. This methodology allows me to ascertain the NO_x emission levels each diesel engine family described in the waiver applications can attain, and what these engine families could attain had the applicants incorporated "state-of-the-art" technology in which a high level of confidence can be placed. This approach has been used by EPA's in assessing technology in conjunction with past decisions on applications for suspension or waiver of statutory motor vehicle exhaust emission standards.[69]

Appendix A addresses whether each engine family is capable of meeting emission standards of 0.41 gpm HC, 1.0 gpm NO_x and 3.4 gpm CO. The pass/fail analysis is performed only for the three regulated pollutants.[70] Consistent with the methodology used in previous suspension decisions,[71] Appendix A presents an evaluation for each engine family for which emission test data were available by using a "Monte Carlo" statistical simulation technique. The highly conservative Monte Carlo technique employs emission test data provided for a vehicle of a given engine family to generate the emission level distributions that would be expected to occur for a large fleet of durability vehicles of that engine family as measured by certification testing.[72] Appendix A assigns a "pass" or "fail" determination to each engine family scenario based on whether the applicable Monte Carlo simulation indicated that at least 80 percent of the vehicles of the engine family in question could meet certification testing requirements for each regulated pollutant if each were tested once.[73] The methodology takes into account the test-to-test, car-to-car, and deterioration factor variabilities which cause uncertainty in projecting from the few test results provided by an applicant whether an engine family can meet certification requirements when tested.[74]

[56] June 20 Tr. 78 (VW).

[57] *Id.* at 65.

[58] *Id.* at 61.

[59] V App., 1–5. Volvo stated that it is not certain it will market the five-cyclinder engine family even if the waiver is granted because Volvo is not sure that the manufacturer of the engine (VW) will sell this engine to Volvo or that this engine can be installed in a Volvo vehicle. June 21 Tr. 47 (V)

[60] June 21 Tr. 7–8 (V).

[61] App., 2.–2.

[62] June 21 Tr. 7–8 (V).

[63] *Id.* at 8 and 34–37. Moreover, Volvo stated that it is presented with an additional problem because it expected the six cylinder diesel engines not in existence at the time it entered into a contract with VW to be similar to four cylinder engines then in existence. The dissimilarity is in the nature of increased emissions from the six cylinder engine. *Id.* The dissimilarity came as a surprise according to Volvo. *Id.* at 25–26.

[64] *Id.* at 7.

[65] *Id.* at 19. Volvo also stated that it appears that it will not be able to market diesel cars in California during the waiver period, 1981 through 1984. *Id.* at 43.

[66] *Id.* at 8.

[67] *Id.* However, Volvo has not done any EGR testing. *Id.* at 34.

[68] Appendix A, §V. Other factors developed but not used are EGR valve replacement, injection pump recalibration, air intake throttling, insulated prechambers and water injection-oxidation catalyst. *Id.* The paucity of data submitted by the applicants made it impossible to obtain factors capable of greater NO_x control. *Id.*

[69] *See, e.g.*, 44 FR 53376, 53380 (Sept. 13, 1979); 40 FR 11908 (March 14, 1975).

[70] Appendix A, § II.

[71] *See, e.g.*, 44 FR 53376, 53380 (Sept. 13, 1979); 43 FR 47272, 47276 (October 13, 1978).

[72] The Monte Carlo technique simulated 100 durability tests on a vehicle with available test data by statistically selecting for each simulated test a set of values for car-to-car, test-to-test, and deterioration rate variabilities over the range of values that could be expected to occur in conjunction with vehicles of the design in question. General Motors used this techique in analyzing emission test data as part of its submission for the proceedings for suspension of the 1975 model year HC and CO standards. *See* 38 FR 10323 (April 26, 1973).

[73] An engine family must have a probability of passing of 80 percent or greater for each pollutant. For example, if the probability of passing for a particular engine family is 79 percent for HC, the engine family fails even though the probabilities of passing for NO_x and CO are much higher than 80 percent. The Administrator applied this 80 percent confidence level in the methodology he used in making his final decision on applications to suspend the 1975 model year HC and CO standards. As Appendix B of that decision explains, EPA has certified many engine families which had not passed certification testing requirements until the second attempt. Because the certification regulations permit an engine family more than one attempt at certifying, the statistical chances of that engine family passing certification testing (by passing on one of the two attempts) are actually greater than 80 percent. In re: Applications for Suspension of 1975 Motor Vehicle Exhaust Emission Standards, Decision of the Administrator, April 1973, (Appendix B).

[74] Although the basic statistical analysis performed pursuant to the Monte Carlo procedure was not altered from that used in previous waiver proceedings, the Monte Carlo procedure had not contained deterioration factors or car-to-car and test-to-test variabilities for diesel-powered vehicles. These factors and variabilities were obtained by analysis of data submitted by the applicants, data

Footnotes continued on next page

This methodology, therefore, increases the reliability of projecting from available test results that an engine family will be able to meet certification requirements. Due to the conservative nature of the Monte Carlo simulation and the high pass rate required (80 percent), a "pass" indicates that this engine family will almost certainly meet certification testing requirements for each regulated pollutant; for the same reason, a "fail" by no means indicates that the engine family cannot meet certification requirements if the manufacturer is willing to accept the added risks.

Appendix A also evaluates the effect of NO_x emission controls on durability and on emissions of particulate matter. This evaluation relies on information supplied by applicants in this proceeding and in the diesel particulate rulemaking proceedings,[75] as well as other information contained in the record for this consolidated decision.

3. Engine Families for Which Waivers Are Necessary

I have determined that three applicants (GM, D–B and Volvo) have shown that waivers are necesary to permit the use of diesel engine technology in five engine families, (GM's 5.7 liter, D–B's 2.4 liter and 3.0 liter naturally aspirated and turbocharged, and Volvo's 2.4 liter naturally aspirated) for model years 1981 and 1982. The emission data presented for three engine families show that emission control technology to meet applicable standards is not available for incorporation into the 1981 model year. GM's 5.7 engine family,[76] D–B's 3.0 liter-turbocharged engine family[77] and Volvo's 2.4 liter naturally aspirated engine family[78] were shown to be incapable of meeting the statutory standards for HC and NO_x in model year 1981. Thus, I have determined that the applicants have met the initial criterion for receiving a waiver for these engine families for model year 1981.

The manufacturers have convinced me that the risks in applying new control technology are sufficient for me to determine that waivers are necessary for these families for model year 1982 because the applicants at this time have little, if any, experience in production of vehicles incorporating the more advanced control technologies that must be used to reduce NO_x emissions to 1.0 gpm. I must consider the risks involved if the applicants are required to incorporate this more advanced control technology into the subject vehicles in 1982. As discussed above, the applicants have raised concerns over driveability, durability, and other problems that may arise if the applicants are forced to introduce the more advanced controls nationwide without first gaining experience in limited production. D–B's position is that granting a waiver for model year 1982 would permit phase-in of the advanced NO_x controls on the subject diesel vehicles in California.[79] I agree with this position. In order to be certified in California in model year 1982, diesel-powered light-duty vehicles must meet the soon-to-be promulgated federal diesel particulate standard and a NO_x standard at least as stringent as 1.0 gpm.[80] Thus, the applicants must incorporate into the subject diesel vehicles for the 1982 California market those advanced NO_x and particulate controls necessary to meet the 1983 model year federal NO_x and particulate standards. Allowing a 1982 California phase-in would mitigate the risks inherent in incorporating advanced control technologies, previously applied only to prototype vehicles, into the production-line fleet. It is not unreasonable to expect that in-use experience of this new control technology will result in the need for adjustments to be made to the vehicles themselves as well as to the production-line operations. Adjustments to vehicles may result in a recall, causing expense and inconvenience to the applicants, their dealers and consumers. A 1982 California phase-in would decrease the potential for a recall of the national diesel fleet, and would permit the applicants to incorporate the adjustments found to be necessary in the 1982 California vehicles into the production-line operations for the model year 1983 national diesel fleet.[81]

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from California auditing, and data from Selective Enforcement Auditing monitored by the EPA. Appendix A, § IV. The diesel factors were then used in the Monte Carlo simulation for the engine families for which adequate data was submitted.

[75] Public Docket No. OMSAPC–78–3.

[76] Appendix A, § VI. A.

[77] *Id.* at § VI. B.

[78] *Id.* at § VI. E.

[79] D–B App., I–35 to I–46; June 18 Tr. 6C (D–B).

[80] Footnote 80 appears on p. 5486.

[81] The Monte Carlo procedure utilized in this technical analysis is designed to project the ability of vehicles equipped with known emission control technology to meet a specific emission standard without reference to a time frame. Hence, the Monte Carlo analysis can be considered to be restrained to a one year time period. The use of technological improvements (factors) can introduce a time element to the Monte Carlo analysis. These technological improvements can have a lead time associated with them, but information concerning the lead time may or may not have been supplied by the applicants. Therefore, the projection of the availability of these technological improvements must be restricted to the 1981–82 period because of the uncertainty of the applicants' intentions. The use of California standards as the forcing function for the introduction and proof testing of emission control technology has been an approach followed previously by EPA, as in the oxidation catalyst phase-in. It is appropriate, therefore to utilize the achieving of the 1982 California standards as the mechanism to promote the emission control technology to achieve a Federal 1.0 gpm NO_x emission standard. I have no reason to believe that the technologies described by the applicants to achieve 1.0 gpm NO_x will not be available by 1982 in Calfironia. Further, the sales fraction of California vehicles allows the applicants to concentrate on emission control technology development, application, and field assessment on a limited number of vehicles, and use these results for transfer to their Federal vehicles for model year 1983. Therefore, I have concluded that the best approach to achieving a 1.0 gpm NO_x standard on a 50 state basis in model year 1983 is to allow the applicants to concentrate on achieving the 1982 California NO_x standards.

A similar phase-in was not required for CO control technology in past decisions because that technology had been phased in by the manufacturers in advance of nationwide marketing.

[80] This 1.0 gpm NO_x standard is optional in California for 100,000 mile certification. If this option is not chosen, a more stringent standard must be met. The California exhaust emissions standards, expressed in grams per vehicle mile, are as follows:

California Emission Standards

Model Year	Vehicle Type(1)	IW	Non-Methane Hydrocarbons(2)	Carbon Monoxide	Oxides of Nitrogen
			Exhaust Emission Standards (g/mi) Useful life of Vehicle		
1981	PC	All	(0.41)	3.4	1.0
	PC(3)	All	0.39(0.41)	7.0	0.7
1982	PC	All	0.39(0.41)	7.0	0.4
	PC	All	0.39(0.41)	7.0	0.7
1983 & Subsequent	PC	All	0.39(0.41)	7.0	0.4
			100,000 Mile Exhaust Emission Standards (g/mi)		
1981	PC(Opt 1)	All	0.39*	3.4	1.5
	PC(Opt 2)	All	0.46	4.0	1.5
1982	PC(Opt 1)	All	(0.41)	7.0	1.0
	PC(Opt 2)	All	0.46	8.3	1.0
1983 & Subsequent	PC	All	0.39(0.41)	7.0	1.0
	PC	All	0.46	8.3	1.0

(1) "PC" means passenger cars

(2) Hydrocarbon standards in parentheses apply to total hydrocarbons

(3) The second set of passenger car standards its optional. A manufacturer must select either the primary or optional sets of standards for its full product line for the entire two-year period.

* In addition to footnote (2) - For vehicles from evaporative emissions families with projected 50,000 mile evaporative emissions values below 1.0 gm/test, an adjustment to the hydrocarbon exhaust emission standard may be granted by the Executive Officer. The adjusted standard will be calculated using the following formula:

$$HC_{ex} = .75\ [.185 - \frac{Di + 3.3\ Hs}{29.9}\ ] + HC_0$$

Where:

HC_{ex} = adjusted exhaust hydrocarbon standard

HC_o = unadjusted exhaust hydrocarbon standard

Di = diurnal evaporative emissions

Hs = hot soak evaporative emission

Moreover, the 1982 phase-in would permit the applicants to identify and correct quality control problems that may arise with the application of the new control technology. The one-year phase-in provides ample opportunity to identify any unacceptable adverse impacts of any new techniques selected by an applicant to meet applicable standards, and to correct such impacts for the national fleet. The California phase-in gives the applicant the opportunity to gain experience in the limited mass production of diesel-powered vehicles equipped with advanced NO_x and particulate controls under conditions of careful quality control while maintaining the accelerating momentum of control technology development.

Only two engine families for which adequate data were submitted were found to be capable of meeting the statutory standards in model year 1981 or 1982 with factors. D–B's 2.4 liter engine family appears to be capable of meeting 1.0 gpm NO_x with increased EGR.[83] D–B's 3.0 liter naturally aspirated engine family appears to be capable of meeting 1.0 gpm NO_x with factors of increased or improved EGR or the Bosch EGR system.[83] However, the effects of these improvements on the durability of the engines (e.g., engine wear) is at best uncertain.[84] Therefore, I conclude that waivers are necessary for the 2.4 liter engine family up to 1.5 gpm NO_x for model year 1981 and up to 1.25 gpm NO_x for model year 1982,[85] and for the 3.0 liter naturally aspirated engine family up to 1.5 gpm NO_x for model years 1981 and 1982. The waivers are necessary for model year 1981 to permit D–B to solve the uncertainty with respect to the durability effects of its advanced NO_x control technology. Necessity for waivers is present when the application of the technology to the subject engine families when it has the potential to cause unacceptable engine wear. The waivers are necessary for model year 1982 to permit D–B to phase-in the advanced controls in California for nationwide application in 1983, as discussed above.[86]

4. Engine Families for Which Waiver Decisions Cannot Be Made

Waivers are denied for the following engine families due to presentation of insufficient data upon which to base a waiver determination:

Manufacturer	Model
D–B	Engine Family ("EF") –1
	EF–2 [87]
GM	4.3 liter
	EF–3
	EF–4
	EF–5 [88]
Peugeot	XD2S
	XD3S [89]
VW	1.6 liter
	1.6 liter turbocharged
	2.0 liter [90]
Volvo	2.0 liter
	2.4 liter turbocharged [91]

[87] Appendix A, § VI.B. D–B submitted no emissions data on either of these two engine families.

[88] *Id.* at § VI.A. GM submitted no emission data on these engine families.

[89] *Id.* at § VI.D. Peugeot submitted no acceptable emissions data for either of these engine families.

[90] *Id.* at § VI.C. VW submitted no acceptable emissions data on these engine families.

[91] *Id.* at § VI.E.

The manufacturers have not presented sufficient information on the technology to be used in the above-listed engine families. They failed to provide emissions data for which the prescribed methodology could be used to evaluate the engine families' respective NO_x emission control capabilities.[92] The applicants received notice prior to and during the public hearings of the inadequacy of information supplied for these engine families.[93]

However, no evidence was presented to permit an assessment of the capabilities of the "no data" families outside the restrictions of the decision methodology.[94]

The Act clearly places the burden of establishing the need for a waiver on the applicant.[95] By failing to supply sufficient data by which I can assess adequately the NO_x emission control capabilities of particular engine families, the applicants have failed to meet the statutory burden. Moreover, no other data is available to me to make the requisite statutory determinations.

Since it is impossible to determine the capabilities of those engine families for which no acceptable emissions data is available, I cannot find that additional lead time is necessary to either develop or phase in control technologies on the subject vehicles in 1981 or later model years. It is possible that the "no data" engine families may be capable of meeting NO_x emission levels below 1.5 gpm without the addition of advanced controls such as additional EGR. Therefore, waivers are denied for those engine families for which insufficient emissions data were submitted.

Of course, the applicants may reapply at any time for waivers for the "no data" families, at which time I will re-examine the availability of effective control technology for those engine families in light of any new emission test data which an applicant may provide.

B. Endangerment to Public Health

In order to grant a waiver request, section 202(b)(6)(B)(i) requires me to determine that a waiver of the statutory standard of 1.0 gpm NO_x would not endanger the public health. This criterion was intended to address the potential health effects of unregulated pollutants from diesel engines as well as the health effects associated with increased NO_x emissions.[96]

[82] Appendix A, § VI. B.

[83] *Id.*

[84] Appendix A, § VI, B. Although D–B submitted little data on the durability issue, the data produced are considered reliable. Once an applicant produces such data that makes a prima facie showing, I bear the burden of showing the reliability of any methodology employed in reaching a decision adverse to the evidence presented by the applicant. *International Harvester Co.* v. *EPA*, 478 F.2d 615 (DC Cir. 1973). In this case I have concluded that I could not reasonably reach a determination that durability problems for D–B's 2.4 liter and 3.0 liter naturally aspirated do not exist. *See* 44 FR 53376, 53383 (Sept. 13, 1979).

[85] D–B sought a waiver up to 1.25 gpm NO_x in 1982 for its 2.4 liter engine family. D–B App., I–18. D–B believes it can certify at 1.25 gpm with no durability problems, and I have no reason to disagree with this belief.

[86] The 1982 phase-in period here is unique due to the lack of present experience with advanced NO_x control technology. However, the ever-accelerating development of technology in this area and the California production phase-in should provide sufficient experience to make phase-in periods beyond 1982 in this area unnecessary.

[92] The guidelines specifically request that such data be included in the applications. Guidelines, 43 FR 30343–45 (July 14, 1978).

[93] Letter from Benjamin R. Jackson, Deputy Assistant Administrator for Mobile Source and Noise Enforcement, EPA, [hereinafter "Letter from Jackson, EPA"] to Dr. Betsy Ancker-Johnson, Vice-President Environmental Activities Staff, GM, June 13, 1979; Letter from Jackson, EPA, to Jerome N. Sonosky, Attorney for D–B, June 14, 1979; Letter from Jackson, EPA, to W. Groth, Administrator of Emissions Regulations and Testing, VW, June 14, 1979; Letter from Jackson, EPA, to R. de Saint Quentin, Peugeot, June 19, 1979.

[94] *See*, Letter from Betsy Ancker-Johnson, Vice-President, Environmental Activities Staff, GM, to Benjamin R. Jackson, Deputy Assistant Administrator for Mobile Source and Noise Enforcement, EPA (hereinafter "to Jackson, EPA"), dated June 19, 1979; GM Supplement to Jackson, EPA, dated July 18, 1979; Letter from Jerome N. Sonosky, of Hogan & Hartson, Counsel, D–B's Supplemental Information, dated July, 1979; VW Supplement, from Wolfgang Groth, Manager, Emission Regulation and Testing, to Jackson, EPA, dated July 13, 1979; Peugeot Supplement, from M. Grossman, U.S. Factory Representative Peugeot, dated July 13, 1979, Volvo Supplement, from S. Wallman, Product Planning, Volvo, dated June 24, 1979.

[95] Clean Air Act, as amended, § 202(b)(6)(B), 42 USC § 7521(b)(6)(B) (Supp. I 1977). I have so interpreted the Act in the Guidelines. Guidelines, 43 FR 30342 (July 14, 1978).

[96] *See, e.g.*, H.R. Rep. No. 294, 95th Cong., 1st Sess. 19, 237, 250–51 (1977); S. Rep. No. 127, 95th Cong., 1st Sess. 70 (1977). The legislative history of the diesel waiver provision makes clear that despite the promising fuel economy benefits of the diesel, its effects on public health were as yet unknown and the subject for continuing concern. The House Committee on Interstate and Foreign Commerce referred to this concern as follows: The Committee points out that the diesel engine historically has had many other problems associated with it. These include: Very high particulate emissions, the

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Accordingly, in comparing the "waiver" and "no-waiver" scenarios, I must assess not only the difference in NO_x emissions levels but also the difference in emission levels of any other regulated or unregulated pollutants.[97]

EPA's waiver guidelines directed the applicants to submit air quality impact studies to quantify the difference in air quality for regulated and unregulated emissions resulting from diesels meeting an interim 1.5 gpm NO_x standard as compared to (1) diesels meeting the statutory 1.0 gpm NO_x standard, and (2) gasoline vehicles meeting statutory standards.[98] The data gathered in these studies were to be factored into health impact studies.[99]

1. Oxides of Nitrogen (NO_x)

a. Air Quality Impact

The waiver guidelines set out several NO_x-related air quality impact considerations to be assessed by the applicants in a comparison between diesels meeting the proposed interim standards and statutory standards. These are the effect on:

(1) Annual regional air quality for NO_x-related pollutants,[100] (2) short term NO_2 levels, and (3) peak NO_x exposure levels at or near roadways. The applicants' assessments were based on the assumption that light-duty diesels would be produced in 1981–84 model years at a 1.5 gpm NO_x level in order to project the effects of a "worst-case" situation in which full, four year waivers are granted to all applicants.

i. Annual Ambient Regional Air Quality Impact

The waiver applicants have claimed that the total change in annual regional NO_x and NO_2 concentrations resulting from a full four year NO_x waiver would be insignificant.[101]

GM estimated a total change in regional NO_x and NO_2 concentrations to be no more than 0.5 percent in late 1984,[102] while D–B and VW predicted a change of less than 0.3 percent from granting the waiver.[103]

EPA's own analysis showed that future ambient levels of NO_x would continue to decrease, even if NO_x waivers were granted to the maximum level (1.5 gpm) for four years.[104] This decrease would be slower than a "no waiver" case only if very high estimates of market penetration of diesels and the NO_x deterioration rates of diesels that would be produced in the period 1981–84 are made.[105] Only if it is assumed that diesel market penetration would be 25 and 50 percent in 1985 with mid-range to high NO_x deterioration rates, would the progress in annual average NO_2 level reductions be slowed by 1 to 2 percent if four year waivers to the maximum interim NO_x level were granted.[106] Since EPA's best estimate for the 1985 market share is 11.4 percent, annual average NO_2 level reductions would continue.[107] Since a two year waiver would have even less of an impact, it may be concluded that there would not be a significant change in annual average NO_2 levels.[108]

ii. Short Term Regional and Roadside NO_2 Impact

GM concluded that total short term regional change in NO_2 concentrations[109] would not exceed 0.5 percent in late 1984, the date of estimated maximum impact, even if all applicants were granted full four year waivers.[110]

EPA's analysis shows that short term NO_2 levels generally will decrease through 1990, and that this trend would be slowed by no more than 1 percent even under a high waiver diesel market penetration estimate of 25–50 percent.[111]

The waiver applicants' analyses of peak one-hour maximum NO_2 exposures from light-duty diesels granted the maximum waiver for model years 1981–84 show that there would be insignificant increases over a "no waiver" situation.[112]

EPA's comparison of waiver/no waiver cases indicates a range in NO_2 levels from no change to an increase of less than 5 percent by 1982 if a two year waiver is granted.[113]

iii. Summary

EPA is in general agreement with the industry that there would be a limited impact on absolute or percentage changes in ambient NO_2 levels resulting from a full four year diesel NO_x waiver. Depending upon the assumptions made concerning market penetration and deterioration rates, the effect of a NO_x waiver on regional, short-term and peak exposure NO_x levels would be relatively insignificant.[114]

EPA's analyses also show that granting a NO_x waiver to all applicants for the two model year period 1981–82 would have an even less significant impact on NO_2 levels.[115] Therefore, I

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chemical composition and potential health effects of which are poorly understood; heavy visible smoke emissions; noxious orders * * * It is expected, therefore, that the Agency and manufacturers will make special efforts to assure that none of these problems will result in endangerment to the public health as a result of widespread use of light-duty diesels. (H.R. Rep. No. 284, 95th Cong., 1st Sess. 250–51 (1977).)

[97] 43 FR 30341, 30345 (July 14, 1978).

[98] *Id.*

[99] *Id.*

[100] This includes data on formation of photochemical oxidants (ozone), which is a result of compelx photochemical reactions involving both hydrocarbons and nitrogen oxides (NO_x). The applicants did not submit data on the effects of waiver on ozone levels. GM stated that it "is virtually impossible to estimate the effect on air quality based on an increase in NO_x emissions of such small magnitude as would result from the proposed waiver." GM App., I–7, III–4. The conclusion reached was that the magnitude of peak oxidant levels would not be affected significantly, and may even decrease as a result of increased NO_x emissions. *Id.* at II–4 and III–B–1. *See, also,* EPA, Appendix B, Air Quality Summary, December 1979 (hereinafter cited as "Appendix B"), § III. B.

[101] *See, e.g.,* GM App., III–3. GM estimated that the maximum incremental increasse in NO_x emissions from granting the waiver would amount to about 0.6 percent of the estimated NO_x emissions from all sources, and this maximum level would not be reached until all "waiver vehicles" were produced and would decrease as the vehicles were removed from service. GM App., III–2.

[102] This estimate was based on the assumption that light-duty diesels would account for 5 percent of the Light Duty Diesel Miles Traveled in 1984, and took into consideration other NO_x sources, stationary and mobile. GM App., III–3. It also assumed that all waiver applicants would be granted a four year waiver to the maximum NO_x level (1.5 gpm).

[103] VW App., 1.–9; D–B App., III–121 to III–125. D–B pointed out that the slight NO_x increased due to higher new car NO_x emissions from diesels compared to gasoline vehicles would be offset over the long term due to emission deterioration in gasoline vehicles. *Id.* at III–121.

[104] Appendix B, § II–A.

[105] Appendix B, Table 3.

[106] *Id.*

[107] *Id.*

[108] Appendix B, § II.B.

[109] Approximately 20 percent of vehicular NO_x emissions are NO_2 emissions, which are not regulated separately. EPA currently is considering establishment of a standard for short-term NO_2 levels.

[110] GM also concluded that since very few Air Quality Control Regions today are out of compliance with the National Ambient Air Quality Standard (NAAQS) for nitrogen dioxide (NO_2), and projected mobile source NO_x reductions should bring all areas into compliance, the predicte NO_2 chanes from a full four year waiver for all applicants would not cause any area to be out of compliance. GM App., Vol. I, III–3, 4. *See also* VW App., I–9.

[111] Appendix B, § II. A.

[112] GM estimated the incremental increase to be .002–.004 ppm (6.5 mg/m^3) under a four year waiver. GM App., III–4. D–B estimated a maximum increase of 1 mg/m^3, and compared this increase to the most stringent hourly standard it assumed was being considered by EPA, 234 mg/m^3. D–B App., III–144. *See also* D–B App., III–154. Production of waiver vehicles was estimated to result in a one hour maximum of .041 ppm, while waiver denial would result in a level of .038 ppm if "statutory diesels" are produced and .037 ppm if no diesels are produced. GM App., III–4.

[113] *See* Cole, Henry S., "The Impact of a NO_x Diesel Waiver on NO_2 Concentrations Downwind of a Major Line Source", May 1979.

[114] Appendix B, § II. A. The same conclusion was reached for oxidant levels. Appendix B, § II. C.

[115] Appendix B, Tables 3, 4.

have concluded that the potential impact on NO_x levels resulting from a NO_x waiver covering five engine families for two model years would not be significant.

b. Public Health Impact

The waiver applicants concluded that the potential increase in ambient NO_2 levels on an annual and hourly basis resulting from a full, four year waiver are insignificant, and therefore, the waiver would not endanger public health. D–B stated that its analyses showed the NO_2 levels projected to occur in a waiver situation would not exceed EPA's existing annual National Ambient Air Quality Standard (NAAQS) for NO_2, or the short-term NO_2 standard being considered by EPA.[116] GM noted that the NO_2 exposure levels used in animal studies which indicate alterations in lung biochemistry are many times greater than the projected concentrations if the diesel waiver is granted.[117]

EPA believes that an appropriate measure of the impact of a waiver on public health is the projected change in ambient NO_2 levels as compared to the NAAQS for NO_2, the level determined by EPA to be protective of the public health.[118] Since EPA's analyses show that granting the waiver would have little impact on the projected decrease in annual ambient NO_2 levels,[119] I believe that waiving the NO_x standard for certain engine families to a level of 1.5 gpm for two model years would not endanger the public health.

2. Unregulated Pollutants

The emissions data submitted by the applicants indicate the presence of several unregulated pollutants in the exhaust of diesel vehicles. D–B and VW submitted generalized (not engine specific) factors for their air quality analyses for unregulated pollutants,[120] while GM provided the results of emissions testing on an experimental 5.7 liter, 8-cylinder diesel, claimed to be representative of GM's primary 1982–84 light-duty diesel production as well as its "worst-case" control problem.[121] Emissions from the experimental vehicle were compared at a high NO_x level (1.24 gpm) and a low NO_x level (.71 gpm), and there was an increase or no change in the level of other pollutants resulting from the reduction in NO_x emissions.[122] GM noted that total aldehyde, particulate and benzo(a)pyrene ("B(a)P") emission levels are increased with the NO_x reduction, so that the waiver would tend to decrease these unregulated pollutants rather than increase them.[123] When GM compared the "statutory" diesel emissions (i.e., 1.0 gpm NO_x) to those of a pre-catalyst gasoline fueled vehicle and a gasoline fueled three-way catalyst equipped vehicle, the diesel emissions showed significantly higher levels of B(a)P, particulates, NO_2, SO_2 and sulfates.[124] However, when GM compared the "waiver" diesel emissions (i.e. 1.5 gpm NO_x) to those of "statutory gasoline" vehicles, the only unregulated pollutants exhibiting higher emission levels were particulates, B(a)P and SO_2.[125]

The generalized data submitted by other waiver applicants indicated similar emissions results. D–B and VW concluded that while NO_x emissions would be reduced by substitution of gasoline-powered vehicles diesels to meet the 1.0 gpm NO_x standard, both CO and HC emissions would increase.[126] The information provided shows that diesel vehicles contribute greater B(a)P and particulate emissions than gasoline vehicles; however, when compared to total highway vehicle emissions, the contribution of the diesel passenger fleet would be negligible. The data also shows that the particulate emissions from the diesel fleet would be approximately one-fourth greater than those of the gasoline fleet,[127] even though the diesel fleet would be relatively smaller.

My concern over increased emissions of currently unregulated pollutants focuses on the air quality and health impacts of diesel particulate emissions. The manufacturers' data show that diesels emit substantially more particulate matter and, as discussed below, of a different composition than gasoline-powered, catalyst vehicles. In addition to the potential for an increase in the incidence of respiratory ailments, there exists the potential that organic components of the diesel particulate are carcinogenic.

a. Particulates

i. Air Quality Impact

In general, diesel-powered vehicles emit 30 to 70 times more particulates than catalyst-equipped gasoline-powered vehicles.[128] Since diesel sales are projected to reach approximately 11 percent of the light-duty market in 1985 and approximately 20 percent in 1990, diesel particulate levels could have a significant impact on local air quality and on the ability of a number of urban areas to meet the primary NAAQS for Total Suspended Particulates (TSP).[129]

EPA currently does not regulate particulate emissions from new motor vehicles. However, EPA recently proposed particulate emissions standards for 1981 and later model year diesel-powered light-duty vehicles and light-duty trucks as required by section 202(a)(2)(A)(iii) of the Act.[130] The proposed standards, required by the Act

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[116] June 18 Tr., 23 (D–B); *see* D–B App., Sec. III. EPA's NAAQS for NO_2 is 0.05 ppm, or 100 mg/m.[3] The short-term (one hour exposure) NO_2 standard being considered is in the range of 0.3 to 0.5 ppm.

[117] GM App., III–5 to III–13. GM concluded that the weight of experimental data clearly indicates that under controlled conditions there is no change is human cardiovascular or pulmonary function for 2 hours of exposure to levels of NO_2 from .05 to 1.0 ppm, both of which are well above the projected .041 ppm concentration if the NO_x waiver is granted. GM also discounted the usefulness of infectivity experiments on the basis that levels of inhaled pathogens are almost always unrealistically high. *Id.* at III–17.

[118] Appendix B, § II. NO_2 is recognized as a respiratory irritant as well as precursor to photochemical smog formation. Existing studies suggest that existing ambient levels of NO_2 may lead to increased acute and/or chronic respiratory diseases. There is no study sufficient to establish a safe level for NO_2.

[119] *Id.* at § II. A; Table 1. EPA, "Air Quality Analysis of Waiving the NO_x Standards for Light-Duty Diesel Vehicles," February 1979.

[120] Appendix B, § III. B.

[121] GM App., III–20, III–21, Tables III–D.2, III D.3.

[122] *Id.* at III–21.

[123] *Id.*

[124] *Id.* at III–22.

[125] *Id.*

[126] D–B App., III–124, Table III–38; VW App. 1–9. Increases in B(a)P emissions were shown to be insignificant. VW estimated that there would be no increase or negligible increases in unregulated pollutants such as sulfates, aldehydes, B(a)P and nitrosamines. VW App., 1.–9.

[127] D–B App., III–124, Table III–39.

[128] U.S. Environmental Protection Agency "Health Effects Associated with Diesel Exhaust Emissions", EPA–600/1–78–063, November 1978 (hereinafter EPA Health Effects Study"), 19–22.

[129] The ambient air quality standard for total suspended particulates (TSP) has been the most difficult for many urban areas to achieve. This is especially true for cities such as St. Louis, Denver, Dallas and Los Angeles. *See* EPA, "The Impact of Future Diesel Emissions on the Air Quality of Large Cities", EPA–450/5–79–005, May 1979. In addition, projected increases in total suspended particulate levels as a result of projected dieselization may have a significant impact on the ability of many urban areas to meet the primary national ambient air quality standard for TSP. *See* EPA, "Draft Regulatory Analysis for Light-Duty Diesel Particulate Regulations," December 22, 1978, at 22–23.

[130] 44 FR 6650 (Feb. 1, 1979). 42 U.S.C. 7521(a)(3)(A)(iii) states that: The Administrator shall prescribe regulations under paragraph (1) of this subsection applicable to emissions of particulate matter from classes or categories of vehicles manufactured during and after model year 1981 (or during any earlier model year, if practicable). Such regulations shall contain standards which reflect the greatest degree of emission reduction achievable through the application of technology which the Administrator determines will be available for the model year to which such standards apply, giving appropriate consideration to the cost of applying such technology within the period of time available to manufacturers and to noise, energy and safety factors associated with the application of such technology. Such standards shall be promulgated and shall take effect as expeditiously as practicable taking into account the period necessary for compliance.

to reflect the best available control technology, were set at 0.6 gpm beginning with the 1981 model year and 0.2 gpm beginning with model year 1983, to reduce particulate emissions from the 1981 uncontrolled level of 1.0 gpm.[131] EPA will promulgate the final diesel particulate standards in the near future. Even if final promulgation includes the most stringent proposed standard of 0.2 gpm, diesel-powered vehicles will continue to emit many times the amount of particulates emitted by catalyst-equipped gasoline vehicles.[132]

The waiver applicants submitted data to show that there would be insignificant increases in projected one hour maximum roadside exposure levels and an insignificant annual increase in TSP levels resulting from granting a four year diesel NO_x waiver, when compared to gasoline only light-duty vehicle emission levels.[133] The manufacturers also submitted data indicating significantly higher projections in 1984 TSP levels if "statutory" diesels are built in compliance with the 1.0 gpm NO_x standard, as compared to "waiver" diesels meeting a 1.5 gpm standard.[134] D–B estimated a 12 percent increase in the 1984 mass particulate emissions inventory if waivers are granted to all applicants, as compared to waiver denial and substitution of gasoline vehicles, and a 20 percent increase if waivers are denied and diesel penetration occurs as projected by D–B.[135] GM concluded that "waiver diesels" showed a 30 percent reduction in particulate one hour roadside exposure level as compared to "statutory diesels".[136] Thus, all applicants concluded that a waiver of the NO_x standard would benefit air quality in terms of particulate levels as compared to emissions from diesels built in compliance with the 1.0 gpm NO_x standard.[137] However, it is undisputed that the projected increase in diesel light-duty vehicle production will increase human exposure to respirable particulates.

ii. Health Impact

Increased emissions of diesel particulates into the ambient air raise two public health concerns. The first is the possible increase in respiratory ailments such as emphysema, bronchitis and asthma. The second is the possibility of increased human exposure to potential carcinogens in the organics associated with/adsorbed onto the diesel particulate. The particulates are composed mainly of carbonaceous matter capable of adsorbing large quantities of extractable organic matter, including known human carcinogens such as B[a]P.[138] In addition, diesel particulates are of a size that can enter and be retained in deep lung compartments, which may enhance the carcinogenic potency of the adsorbed organic matter.[139]

Positive results from a wide variety of tests suggest that the organics emitted with the diesel particulates contain carcinogens. Extracts of diesel particulates have been shown to be mutagenic in the Ames Salmonella/microsome test, to cause *in vitro* transformation in mammalian cell structure,[140] and to cause skin cancer when painted on mice.[141] These results are only "suggestive" evidence that diesel particulates cause cancer in humans.[142] EPA's ongoing research program to determine the mutagenicity/carcinogenicity of diesel exhaust will generate more data in the future, including results from whole animal studies to determine its potency as a carcinogen.[143]

Current evidence of the risk of human cancer from diesel particulate emissions, based on epidemiological studies conducted on populations exposed to high levels of diesel particulates, is contradictory at best.[144] The manufacturers generally concluded from a review of the current epidemiological studies that there is little or no evidence of any transient or permanent health effects at the concentrations of diesel particulates predicted to occur by 1984 as a result of the waiver.[145] Although there is no definitive epidemiologic evidence suggesting cancer risk from exposure to diesel particulates, estimates have been made on the cancer risk based on assumptions made for purposes of analysis.[146] The estimate is preliminary in nature, and more information is being gathered on the chemical constituents and biological activity of diesel exhaust to form a more complete data base for future assessment of the potential cancer risk.[147]

The manufacturers assert that the growth of the light-duty diesel population does not, at our current state of knowledge, threaten any adverse effects on public health.[148] However, I conclude that the uncertainty surrounding the potential risk posed by diesel particulates warrants a cautionary approach in this proceeding.

(a) Assessment of Risks—Granting or Denying Waivers

To the extent that waivers are granted, the applicants will be able to market diesel vehicles that emit more particulates than would gasoline-powered vehicles. However my assessment of the risk posed by these emissions must be made in light of the greater risk posed by the particulate emission levels that might result from waiver denial. Section 202(b)(6)(b) does not authorize me to prevent the manufacture and sale of diesels; rather, I may grant or deny a manufacturer's request to permit a particular diesel engine family to meet a NO_x standard less stringent than 1.0 gpm. Waiver denial does not necessarily prevent a

[131] 44 FR 6650, 6651 (Feb. 1, 1979).

[132] See *supra* note 128.

[133] GM estimated that the National Ambient Air Quality Standard (NAAQS) for particulates for a 24-hour average would remain well above the projected one-hour maximum roadside particulate contributions from diesel light-duty vehicles. *Id.* at III–23. The primary National Ambient Air Quality Standard for particulates has been set at 75 mg/m^3 as an annual geometric mean over 24-hour values, and 260 mg/m^3 as a 24-hour maximum, not to be exceeded more than one per year. GM pointed out that the increase in annual TSP levels caused by diesel light-duty vehicles (estimated to be 1 percent) is very close to the reduction in lead particulate emissions that will occur between now and 1985, so that the light-duty vehicle contribution to regional TSP levels will remain relatively constant. *Id.* III–24. This ignores the qualitative difference between diesel and lead particulates. D–B concluded that projected 1984 light-duty diesel particulate emissions would constitute only about 2 percent of the 1977 national inventory of total man-made particulates. D–B App., III 118.

[134] D–B App., III–118, Table III–33; GM App., III–23 to III–24.

[135] D–B App., III–128, Table III–39.

[136] GM App., III–23, Table III–B.2.

[137] This argument is based on the manufacturers' assertions that controlling NO_x emissions increases diesel particulate levels. *See, e.g.*, GM App., III–24, 25; June 19 Tr. 247, 152.

[138] EPA Health Effects Study, 95–100, 149.

[139] EPA Health Effects Study, 12–52.

[140] Huisingh, et al., "Mutagen and Carcinogenic Potency of Extracts of Diesel and Related Environmental Emissions," Int'l Symposium on Health Effects of Diesel Engine Emissions (hereinafter "Diesel Symposium") Session V, December 3, 1979.

[141] Kotin, P., H. L. Falk, M. Thomas, "Aromatic Hydrocarbons III: Presence in the Particulate Phase of Diesel-Engine Exhausts and the Carcinogenicity of Exhaust Extracts", AAM Arch. Ind. Health *II*, 113–120 (1955).

[142] 44 FR 39858, 39861 (July 6, 1979) ("Scientific Bases for Identification of Potential Carcinogens and Estimation of Risks").

[143] EPA, Office of Research and Development, "Mobile Source Research Plan of the Mobile Source Research Committee", January 24, 1979.

[144] Calabrese, E., "A Review of the Literature: Health Effects Associated with Exposure to Diesel Fuel Exhaust," Diesel Symposium, Session VIII, December 3, 1979.

[145] GM App., III–32; D–B App., III–6.

[146] EPA Cancer Assessment Group, Initial Review of the Potential Carcinogenic Impact of Diesel Exhaust (June 11, 1979) [hereinafter "CAG Study"], 6. The estimate was based on the assumption that 25 percent of the light-duty vehicle fleet were dieselized with uncontrolled particulate emissions (i.e., 1.08 gpm).

[147] *See* CAG Study, 2.

[148] *See e.g.*, GM App., III–24–25; D–B App., III–6; June 18 Tr. 20 (D–B).

manufacturer from attempting to certify a diesel engine family for which a waiver has been denied. The manufacturer may choose not to manufacture the diesel engine family, or to attempt to certify and manufacture it in compliance with the 1.0 gpm NO_x standard. If the manufacturer chooses the former, it may replace the diesels with comparable gasoline-powered vehicles, with negligible particulate emissions. However, if the manufacturer chooses the latter and I grant a certificate of conformity so that the diesels may be marketed at 1.0 gpm NO_x, particulate emissions may be significantly higher than diesels meeting a less stringent NO_x standard. The conservative nature of the technology assessment makes this a genuine possibility notwithstanding my determination that the waiver is necessary to permit use of diesel technology in the subject vehicles.

All waiver applicants have claimed that they cannot meet both a 1.0 gpm NO_x standard and EPA's proposed 0.6 gpm diesel particulate standard with currently available technology. They stressed that if forced to meet a 1.0 gpm NO_x standard, emissions of HC, CO, particulates and other unregulated emissions would increase.[149] This is based on the assertion that the amount of EGR, the primary NO_x control technology currently available, necessary to reduce NO_x to a level in the range of 1.5 gpm to 1.0 gpm, tends to increase levels of other emissions, especially particulates.[150] Although little data was submited to demonstrate this relationship, each manufacturer stated that particulate emissions increase as a result of increasing EGR rates to reduce NO_x from 1.5 gpm to 1.0 gpm.[151] EPA's analyses show that increasing use of EGR to reduce NO_x to the statutory level of 1.0 gpm would place upward pressure on particulate emissions.[152] Regarding the extent of this effect, GM stated that particulates increase proportionately to percentage decreases in NO_x emissions.[153] Therefore, it appears that the manufacturers will use EGR to meet a NO_x standard of 1.5 gpm on most of their vehicles, and that EGR would have to be increased to approach a 1.0 gpm standard.[154] GM and D–B stressed that waiving the statutory NO_x standard would improve air quality in terms of TSP and other unregulated pollutants, while ambient NO_x levels (except NO_2) would continue to decrease.[155] DB also stressed that granting the NO_x waiver would result in an 8 percent decrease in motor vehicle particulate emissions, compared to a non-waiver situation in which diesel vehicles meet the statutory NO_x standards.[156]

Granting the waivers to the five engine families for model years 1981 and 1982 would result in an increase in NO_x emissions compared to those if the engine families were manufactured to meet 1.0 gpm Nox. However, the waiver vehicles would still be required to meet a more stringent NO_x standard in 1981 than the 1980 model year NO_x standard of 2.0 gpm. The waivers would merely delay the mandated decrease in NO_x emissions from 2.0 gpm to 1.0 gpm while still requiring a decrease to 1.5 gpm NO_x. As discussed above, the delayed decrease in NO_x emissions from a full two year waiver would merely slow the trend of decreasing NO_x emissions from all sources nationwide. Athough NO_x emissions control remains an important aspect of vehicle emissions control, I must balance the risks associated with an incremental NO_x increase with the risks from incremental particulate emissions increases.

If I were to deny the waivers, and the manufacturers were to replace the five diesel engine families with comparable gasoline-powered vehicles, diesel particulates would pose no health risk, and the balance would favor denying the waiver since both NO_x and particulate emissions would be reduced. However, there is the real possibility that the five engine families could be produced for model years 1981 and 1982 to meet 1.0 gpm NO_x. Implicit in the manufacturers' claims that air quality benefits will result from a waiver is the assumption that the light-duty diesels will be marketed regardless of the outcome of the NO_x waiver. Rather than assuming that gasoline vehicles would replace diesels in a "no waiver" scenario, the manufacturers assumed in the "no waiver" situation that diesels would emit more particulates.[157] D–B stated that if it were forced to meet the 1.0 NO_x standard, it would have to apply "Stage I EGR" to its diesels, which would increase HC, particulates and other unregulated emissions.[158] GM admitted that it could not say that if a waiver were denied it could not make diesels,[159] and assumed in the "no-waiver" case that particulates would increase to a 1.0 gpm level, rather than assuming a decrease in particulate emissions from substitution of gasoline vehicles.[160]

It also appears that the manufacturers are committed to producing light-duty diesels, at least in the short term. GM stated that it has in place the capital equipment and assembly facilities for producing diesels,[161] and claimed that significant economic disruption would result from waiver denial due to its inability to substitute gasoline-powered vehicles for its projected diesel production.[162] The foreign manufacturers also predicted economic disruption if they were unable to market diesels in the United States.[163]

Thus, there appears to be a real possibility of diesel production even if all waiver requests are denied notwithstanding EPA's evaluation of the manufacturers' technological capabilities. That manufacturers may attempt and succeed in certifying diesel vehicles capable of meeting the 1.0 gpm NO_x standard in 1981, even though the methodology employed by EPA indicates a risk of failure that they would be able to do so, does not mean that EPA's methodology is inappropriate for assessing technological feasibility. The Monte Carlo analysis is highly conservative in order to assure that an engine family that receives a "pass" would almost certainly pass certification requirements. In this sense, the methodology contains a margin of error to provide manufacturers with a cushion for the risks of production. This is necessary because the consequences of discovering at a later date that a manufacturer cannot comply after development and production

[149] *See, e.g.*, June 18 Tr., 23 (D–B); June 19 Tr., 5 (GM).

[150] June 19 Tr. 5, 52, 86–87 (GM). GM stated that only slight additions of EGR were necessary to meet a 1.5 gpm NO_x standard (June 19 Tr., 86) but that large amounts were needed to meet a 1.0 gpm NO_x standard, resulting in increased emissions of other pollutants, especially particulates (June 19 Tr., 5). See note 146, *supra*.

[151] June 19 Tr., 5 (GM); June 18 Tr. 25–26, 130–132, 103 (D–B).

[152] When EPA applied EGR factors to no-EGR test vehicles (e.g., GM 5.7 liter; D–B's 2.4 liter), upward pressure on particulate emissions resulted in most cases. Appendix A, § V.

[153] June 19 Tr., 5–6 (GM).

[154] For example, D–B stated that if forced to meet a 1.0 gpm NO_x standard in 1981, it would have to apply "Stage I EGR", which increases HC, particulates and other unregulated emissions. June 18 Tr., 130; D–B App.; II–21 to II–27.

[155] June 18 Tr. 23–26 (D–B); June 19 Tr., 247–261 (GM).

[156] June 18 Tr. 25–26 (D–B).

[157] *See e.g.*, June 19 Tr., 249 (D–B).

[158] June 18 Tr., 130–31 (D–B).

[159] June 19 Tr., 125 (GM).

[160] June 19 Tr., 249 (GM).

[161] June 19 Tr., 123 (GM).

[162] GM App., I–3 to I–4; June 19 Tr., 125 (GM). GM's argument that it could not substitute gasoline vehicles for its projected diesel production is based on: (1) Its inability to meet the CAFE standards with its family-size cars; (2) the lack of demand for additional small-size gasoline cars; (3) its inability to tool up for the production change within the remaining lead time.

[163] D–B App., I–7 to I–8, V App., 1–3; VW App., 1–5; June 18 Tr., 61–64 (D–B).

commitments are made could have serious economic consequences.[164]

However, failing the Monte Carlo analysis does not indicate that the engine family would not actually meet certification requirements. The methodology does not and should not factor in the possibility that, despite the high risks involved, manufacturers will make an all out effort (and possibly succeed) to certify and market complying vehicles. Apparently, the economic incentives of marketing diesel vehicles have increased the magnitude of risk which the manufacturers are willing to take. Thus, there is still a substantial probability that an engine family which fails the Monte Carlo analysis can meet certification requirements. These engine families would most likely incorporate simple EGR which would increase particulate emissions in order to meet 1.0 gpm NO_x.[165]

Therefore, with respect to the three engine families that failed the Monte Carlo analysis for model year 1981 (GM's 5.7 liter, D–B's 3.0 liter turbocharged, and Volvo's 2.4 liter naturally aspirated engine families), such failure in no way prevents the manufacturers from certifying these engine families in model year 1981. Similarly, there has been no showing that the three engine families could not be manufactured for the nationwide market in model year 1982 to meet 1.0 gpm NO_x. Rather, I have determined that waivers are necessary for model year 1982 to permit a more efficient and effective phase-in of more advanced control technologies needed to meet 1.0 gpm NO_x with adequate particulate emissions control. Without a phase-in, the manufacturers might find it necessary to utilize less effective control technology in their nationwide diesel fleets, which may limit NO_x emissions to 1.0 gpm but which may also significantly increase particulate emissions.[166]

The two D–B engine families (2.4 liter and 3.0 liter naturally aspirated) that passed the Monte Carlo analysis for model year 1981 could almost certainly meet certification requirements at 1.0 gpm NO_x, and therefore the probability is high that the two engine families would be marketed in 1981 and 1982 if waivers are denied. The non-waiver diesels would emit higher levels of particulates than waiver diesels due to increased use of simple EGR.[167]

(b) Assessment of Relative Risks—Health Impact

Due to the possibility that the five engine families would be produced at a 1.0 gpm NO_x level in 1981 and 1982 with significantly higher particulate emissions, I have determined that the risk of harm to the public health from such an increase in diesel particulate emissions accompanying a waiver denial outweighs the health impact from requiring a smaller decrease in light-duty vehicular NO_x emissions from the 1980 level of 2.0 gpm. The likelihood of serious harm from an increase in diesel particulates accompanying waiver denial is more substantial than the potential harm from delaying a decrease in NO_x emissions due to the uncertainty surrounding current evidence suggesting a risk of human cancer from diesel exhaust, as well as the presence of known human carcinogens in diesel exhaust. The probability that human exposure to diesel particulates would pose a serious threat to the public health is uncertain; yet, the harm to be avoided, cancer, is sufficiently serious to justify preventative action under the "endangerment" standard.[168] Additional evidence on the levels of exposure necessary for adverse effects to occur, as well as the potency of diesel particulate matter as a human carcinogen, is necessary before any firm judgments are made.

However, I deem the preliminary evidence of a potential cancer problem sufficent to merit action that will minimize particulate emissions from the light-duty diesels. Granting the NO_x waiver to the five engine families for two model years will allow the manufacturers to achieve lower particulate levels than if required to meet the statutory NO_x standard. Although diesel particulate emissions would increase only if "statutory" diesels were built, the risk is substantial enough to cause me to choose the alternative which results in lower particulate levels, especially since preliminary scientific assessment may have underestimasted the potential health risk.[169]

I am choosing to avoid the risk that light-duty diesels will be produced at lower NO_x but higher particulate levels, in order to minimize the potential problem in the short term.[170] Thus, I believe that granting the NO_x waiver for those vehicles which would otherwise emit significantly more particulates if required to meet a 1.0 gpm NO_x standard is more protective of public health than waiver denial.[171]

(c) Limited Scope of Determination and Future Regulation

This decision turns on the data produced by the manufacturers indicating that increased use of EGR necessary to meet the 1.0 gpm NO_x standard in the waiver vehicles would force a significant increase in particulate emissions. In view of the incomplete but suggestive evidence that diesel particulates may pose a threat of increased incidence of human cancer, I believe that the risk of severe harm to the public health demands that I grant the subject waivers. However, my determination that the waivers would not endanger public health is limited in scope. It applies only to diesel vehicles which EPA has concluded would emit significantly more particulates if required to meet the statutory standard, and applies only for a period necessary for the manufacturers to refine the technologies needed to control NO_x and diesel particulate emissions.

I must caution the manufacturers, however, that this decision does not represent an open door to future production of light-duty diesels without great emphasis on developing methods to identify, characterize and control diesel-related emissions. First, the manufacturers should emphasize particulate emissions control while attempting to certify in California their diesel light-duty vehicles at a 1.0 gpm NO_x level. Second, they should use the "California phase-in" as an opportunity to test their most advanced NO_x control systems to avoid increasing particulate emissions while reducing NO_x emissions to the 1.0 gpm level.[172]

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[164] *See International Harvester v. EPA*, 478 F.2d 615, 630 (D.C. Cir. 1973).

[165] Appendix A, § V (GM's 5.7 liter, and Volvo's 2.4 liter naturally aspirated). D–B is expected to use an advanced Exhaust Gas Recirculation (EGR) system on its 3.0 liter-turbocharged engine family to meet the 1.0 gpm NO_x standard (*Id.* at § VI), and advanced EGR may increase particulate emissions. *See also*, June 19 Tr., 124–25 (GM).

[166] *See infra* note 171.

[167] *See infra* notes 150–52.

[168] *See Ethyl Corp.* v. *EPA*, 541 F.2d at 19, *citing Reserve Mining Co.* v. *EPA*, *supra*.

[169] *See* EDF Comments, 9–10; Appendix B, § III.C.

[170] Since the manufacturers contend they cannot meet the 1.0 gpm NO_x standard and EPA's proposed 0.6 gpm diesel TP standard, it is possible that EPA's proposed diesel TP standards for 1981 and later model years would have to be changed if the manufacturers were required to meet a 1.0 gpm NO_x standard, because the TP standard is technology-based.

[171] I cannot make a determination on the public health impact of granting or denying a waiver for those engine families for which inadequate data was submitted to show need for a waiver ("no data families"). It is possible that no data families would not require use of additional EGR to reduce NO_x emissions to 1.0 gpm, so that there would be no upward pressure on particulate emissions. Therefore, granting the waiver for the no data families would not necessarily be more protective of public health than denying the waiver.

[172] The technological improvements which may enable manufacturers to met the 1.0 gpm NO_x standard without necessarily increasing particulate emissions include: EGR valve replacement, injection pump recalibration, air intake throttling, insulated prechambers, water injection-oxidation catalyst, and inertia weight reduction. *See* Appendix A, § V.

Since the manufacturers themselves have argued their need for a NO_x waiver so that they can meet EPA's proposed diesel particulate emission standards and to give them an opportunity to introduce their more effective control technologies into the 1982 California market, this decision should enable them to fully comply with the final diesel particulate standard promulgated by EPA while meeting California's 1982 emission standards.

In addition, the manufacturers should continue to study the components and health effects of diesel emissions and should work with EPA to assess and alleviate potential health problems. EPA's research program to assess the public health significance of diesel emissions [173] will continue to generate health effects data, which may indicate a need for EPA to take regulatory action in this area. As indicated above, this proceeding does not allow me to control production of light-duty diesels or emissions levels of pollutants other NO_x.[174] However, I must caution the manufacturers to proceed with the full realization that EPA has the authority to act in the future under other provisions of the Act to prevent diesel emissions from posing an unacceptable risk to public health.[175]

C. *Fuel Economy*

The fuel economy benefit of diesel vehicles was a major consideration in the enactment of the diesel NO_x waiver provision.[176] The manufacturers have stressed the fuel economy benefits in their applications [177] and at the public hearings.[178] The manufacturers estimate this benefit to be an improvement over gasoline-powered vehicles of between 25 and 50 per cent.[179]

Fuel economy considerations are contained in the second and third criteria of section 202(b)(6) (B).[180] The second criterion provides that a waiver may be granted if I determine that it will result in significant fuel savings at least equal to the fuel economy standard applicable in each year under the Energy Policy and Conservation Act [EPCA].[181] To meet this criterion, the applicant must show that the "base level" for the class or category for which a waiver is requested will meet the applicable EPCA fuel economy standard.[182] The fuel economy standard for the 1981 model year is 22 miles per gallon (mpg) and the standard for the 1982 model year is 24 mpg.[183] All of the base levels of the engine families listed in the summary will meet or exceed the fuel economy standards for 1981 and 1982.[184]

The third criterion provides that a waiver may be granted if I determine that the diesel engine technology has the potential to meet or exceed the average fuel economy standard applicable under EPCA at the expiration of the waiver. To meet this criterion, the applicant must show that there is a substantial likelihood that the average fuel economy of the applicant's diesel fleet will meet or exceed the EPCA standard.[185] The EPCA standard for 1983, the expiration year of the waivers, is 26 mpg.[186] I find that there is a substantial likelihood that the average fuel economy of the diesel fleets of the applicants listed in the summary (GM, D–B and Volvo) will meet or exceed 26 mpg.[187]

D. *Long Term Air Quality Benefit*

In order for a waiver to be granted the applicant must show that diesel engine technology has the potential for long-term air quality benefit.[188] This criterion is met if there is a substantial likelihood that the engines will be able to comply with the statutory emissions standards applicable at the expiration of the waiver period.[189] The statutory standards applicable at the expiration of the waiver period, model year 1983, are, in addition to the 1.0 gpm NO_x standard, standards of 3.4 gpm for emissions of carbon monoxide (CO) and 0.41 gpm for emissions of hydrocarbons (HC).[190]

I have found that a small-scale phase-in of the technology necessary to meet a 1.0 gpm NO_x standard in California in model year 1982 to be necessary to avoid risks in nationwide production of the 49-state fleet. As discussed previously, the California phase-in will provide an adequate proving ground for diesel emission control technologies [191] necessary to meet a 1.0 gpm NO_x standard.[192] Therefore, there is a

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[173] Barth, D. and Blacker, S., "The EPA Program To Assess The Public Health Significance of Diesel Emissions", 28 *Journal of the Air Pollution Control Association* 769, August 1978.

[174] I have been urged to deny all waiver requests on the ground that I cannot make an affirmative determination that the diesel technology would not endanger public health, in view of the evidence suggesting a cancer risk. EDF Comments 9–10; Comments of the Natural Resources Defense Council, July 13, 1979; Comments of the American Lung Association, June 1979. However, I do not believe that this proceeding is the proper forum for assessing the relative risks associated with gasoline vehicle emissions and diesel emissions for the following reasons. First, the "waiver," although presumably necessary to permit use of diesel technology in the particular vehicle class, is not a necessary condition to increased production of light-duty diesels, and waiver denial is not sufficient to ensure that gasoline vehicles would be substituted. Second, Congress made specific provision in section 202(a)(4) of the Act for the balancing of health risks from emissions of unregulated pollutants associated with competing technologies. (42 U.S.C. 7521(a)(4) (Supp. I 1977).) Applicants for vehicle certification must explore reasonably foreseeable problems or potential problems associated with unregulated pollutants emitted from the vehicle technology, and make an adequate showing that the system would not cause or contribute to an unreasonable risk to public health, welfare and safety. My assessment of the vehicle technologies for which certification is requested necessarily involves a comparison between the unregulated pollutant risks of the standard internal combustion gasoline-powered engine and those of the competing technologies (See H.R., No. 294, 95th Cong., 1st Sess. 276–79 (May 12, 1977)). This section authorizes me to deny applications for certificates of conformity if the vehicle manufacturer fails to meet the burden of proof; therefore, controlling production of a suspect vehicle technology is dealt with more appropriately under section 202(a)(4). When the manufacturers apply for certification for the 1981 model year, I will be in a position to and will deermine, as in previous model years since 1979, whether the vehicles presented for certification (diesels and other systems) will pose an unreasonable risk to public health, welfare and safety.

[175] 42 U.S.C. 7521(a)(4), 7525(a)(3) (Supp. I 1977); H.R. Rep. No. 294, 95th Cong., 1st Sess. 29, 237, 250–51 (1977).

[176] Guidelines, 43 FR 30342 (July 14, 1978); *See, supra*, note 3.

[177] GM App. I–7; D–B App. I–16 and IV–1; P App. 1–4; VW App. 1–12; V App. 1–3 to 1–4.

[178] *See, e.g.*, June 19 Tr. 138.

[179] June 19 Tr., 138 (GM) (25 percent); P App. 1–4 (30 percent for city driving); VW App. § 1–12 (50 percent). EPA is currently re-evaluating the "fuel equivalency factor" (under 40 CFR 600.510–80(b)(2)(iii)) between diesel fuel and gasoline of 1:1 in order to determine whether these estimates are accurate. Under the present ratio, the miles per gallon (mpg) of one gallon of gasoline may be directly compared to mpg of one gallon of diesel fuel for equivalent vehicles without any corrective factor.

[180] Clean Air Act, as amended. § 202(b)(6)(B)(ii) and (iii). 42 U.S.C. 7521(b)(6)(B)(ii) and (iii) (Supp. I 1977).

[181] Sections 502(a)(i) of EPCA establishes fuel economy standards for 1978–80 and 1985 and thereafter and provides the Secretary of Transportation with the authority to promulgate standards for 1981–84. 15 U.S.C. 2002(a)(1)(1975).

[182] Guidelines, 43 FR 30343 (July 14, 1978). Base level means "a unique combination of basic engine, inertia weight, and transmission class." 40 CFR 600.002–77(23) (1977).

[183] 49 CFR 531.5 (1978).

[184] Appendix A, § VII; V App. 4–1; VW App. 4–3; D–B App. I–15 to I–16, IV–1, Exhibit C.

[185] Average fuel economy means "the production-weighted combined fuel economy value of all passenger automobiles produced by a manufacturer in a single model year as computed in 40 CFR 600.510" 40 CFR 600.002–77 (14) (1977).

[186] 49 CFR 531.5 (1978).

[187] Appendix A, § VII: *See also*, VW App., 1.–12. 4.–1 to 4.–2; D–B App., I–15 to I–16, IV–1, Exhibit C. The reference to "technology" and the inclusion of the word "average" in the third criterion clearly evinces an intent on the part of Congress that I look at the entire diesel technology of an applicant at the expiration of a waiver period.

[188] 42 U.S.C. 7521(b)(6)(B)(iii) (Supp. I 1977).

[189] *See* 123 Cong. Rec. 13703 (Aug. 4, 1977) (remarks of Senator Muskie); *see also* 43 Fed. Reg. 30343, 30347 (July 14, 1978).

[190] 42 U.S.C. 7521(b)(1) (A), (B) (Supp. I 1977).

[191] See discussion of applicants' proposed emission control systems in section III. A. 1. of text.

[192] The manufacturers must meet, as a minimum, standards of 1.0 gpm NO_x, .41 gpm HC and 7.0 gpm CO for light-duty vehicles in the 1982 model year in California. Since diesel engine technology exhibits lower CO emission levels than gasoline vehicles, the manufacturers should not have any problem meeting the federal CO standard of 3.4 gpm in 1983.

Footnotes continued on next page

substantial likelihood that these vehicles will meet the Federal statutory standards in model year 1983.

IV. Final Decision and Amended Rule

Section 202(b)(6)(B) of the Act grants me the authority to waive the statutory standard of 1.0 gpm NOx and to prescribe interim standards which provide that NOx emissions may not exceed 1.5 gpm for any class or category of diesel light-duty vehicles or engines manufactured during model years 1981, 1982, 1983 and/or 1984 which meet the statutory waiver criteria. Based upon the foregoing discussion of the classes or categories for which waiver applications were made, I hereby am prescribing the interim standards for five engine families for model years 1981 and 1982 as follows:

Manufacturer	Engine family	Model year	Interim standard (gpm)
Daimler-Benz	2.4 liter	1981	1.5
		1982	1.25
	3.0 liter naturally aspirated	1981-1982	1.5
	3.0 liter turbocharged		1.5
General Motors	5.7 liter	1981-1982	1.5
Volvo	6 cylinder, 2.4 liter naturally aspirated	1981-1982	1.5

Part 86 of Chapter I, Title 40 of the Code of Federal Regulations, as applicable to 1981 and later model year diesel-powered light-duty vehicles, is amended below. (See FR Doc. 80-1858 which follows).

Dated: December 21, 1979.

Douglas M. Costle,

Administrator.

Appendix A—Summary of Technological Capability

Contents

I. Introduction
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I. Introduction

The existing exhaust emission standards for light duty vehicles are 0.41 grams per mile HC, 3.4 grams per mile CO, and 1.0 grams per mile NO_x for model year 1981. Section 202(b)(6)(B) of the Clean Air Act, as amended, (42 U.S.C. 7521(b)(6)(B)) provides a waiver procedure by which a manufacturer may apply for relaxation of the 1.0 gram per mile NO_x standard up to 1.5 grams per mile for some period during model years 1981 through 1984 for Diesel-powered vehicles. Five vehicle manufacturers have applied for this waiver. These manufacturers are General Motors, Daimler-Benz, Volkswagen, Peugeot, and Volvo.

This appendix reviews the technological capability of the applicant manufacturers to meet the 1981 and subsequent model year NO_x standard of 1.0 grams per mile. The analysis contained in this appendix continues and relies on analyses contained in three previous technical appendices, particularly for the discussion of the Monte Carlo similation utilized in the technological capability analysis presented in this appendix. These referenced appendices are:

1. Appendix B, Technical Appendix to the Decision of the Administrator in Remand for the United States Court of Appeals for the District of Columbia Circuit, April 11, 1973.
2. Appendix A, Technical Appendix to the Decision of the Administrator in re: Applications for Suspension of the 1976 Motor Vehicle Exhaust Emission Standards, July 30, 1973.
3. Appendix A, Technical Appendix to the Decision of the Administrator in re: Applications for Suspension of the 1977 Motor Vehicle Exhaust Emission Standards, March 5, 1975.

As indicated in Section 202(b)(6)(B), the technological feasibility evaluation performed the technical staff is made with respect to the technological capability of the applicants to determine whether or not a waiver is necessary to permit the use of Diesel engine technology.

II. Summary of Technological Capabilities

Tables II–1 through II–5 are a summary of the applicant's capabilities in achieving 0.41 HC, 3.4 CO, and 1.0 NO_x for the Diesel-powered vehicles that were submitted in the applications for the NO_x waiver.

The key to the summary tables is as follows. The first five columns refer to analysis of the vehicles in an as-received condition, i.e., without any technological improvements applied to these vehicles. The first column lists the engine families. The second column is the number of vehicles in that engine family that were evaluated through the Monte Carlo analysis. The third column is the number of vehicles that passed or failed the Monte Carlo analysis. The fourth column is the reason for these failures, that is, which of the exhaust emissions were determined to have less than an 80 per cent chance of certifying when it was evaluated in the Monte Carlo analysis. The fifth column is the probability of passing the particular standards as generated by the Monte Carlo analysis.

Columns six through ten reflect the "technological improvements" applied to the as-received vehicles. Column six refers to the vehicles that were used for the Monte Carlo analysis. Column seven is a shorthand notation of the factors that were applied to the vehicles. This notation is further developed and explained in Section V. Column eight refers to the number of vehicles again that passed or failed, this time with the improvements applied. Column nine is the reason for the failure, if the vehicle indeed failed, and whether it was a HC, CO, or NO_x failure. Column ten refers to the probabilities for HC, CO, or NO_x that go along with the indication of a failure.

The "no data" category is an abbreviated notation for the lack of acceptable data to perform EPA's technological analysis. Applicants have, for several years, known the types of data necessary for EPA to make a determination whether or not a given vehicle would be projected to pass or fail a set of standards. Unfortunately, in many cases there were a lack of acceptable data for specific engine families. This effectively precluded EPA from making a pass/fail determination for those families. In these cases, the families are called no data and no pass/fail determination was made.

In the technological analysis, data from prior year's certification programs were not used. These data were not used because the technology and calibrations employed on these vehicles were not representative of the technology and calibrations that will be used for model year 1981. Vehicles designed and calibrated for much different, more lenient, emission standards then those at issue here have little relevance to a forecast of techonological availability.

Footnotes continued from last page
Moreover, EPA's analysis indicates that application of NO_x control technology necessary to meet the 1.0 gpm NO_x standard does not increase CO emissions above a 3.4 gpm level. Appendix A. Tables II–1, II–2, II–5.

Table II-1.—*General Motors*

[0.41 HC, 3.4 CO, 1.0 NO_x]

Engine family and number of vehicles	W/O factors								W/factor applied							
	Vehicles P/F		Reasons for failures			Probability			Vehicle	Factor	Vehicles P/F		Reason for failures			Probability		
	P	F	HC	CO	NO_x	HC	CO	NO_x			P	F	HC	CO	NO_x	HC	CO	NO_x
4.3/									No data									
5.7/—1	0	1	X	—	X	31	100	0	1	A	—	X	X	—	X	43	100	0
										B	—	X	X	—	X	38	100	0
										C	—	X	X	—	X	56	100	0
												X	X	—	X	36	100	0
										E	—	X	X	—	—	10	100	100
Other engine families									No data									

Table II-2.—*Daimler Benz*

[0.41 HC, 3.4 CO, 1.0 NO_x]

Engine family and number of vehicles	W/O factors								W/factor applied							
	Vehicles P/F		Reasons for failures			Probability			Vehicle	Factor	Vehicles P/F		Reason for failures			Probability		
	P	F	HC	CO	NO_x	HC	CO	NO_x			P	F	HC	CO	NO_x	HC	CO	NO_x
2.4/—1	0	1	—	—	X	97	100	0	1	A	X	—	—	—	—	84	100	99
3.0/-NA—3	0	3	—	—	X	84	100	71	1	A	X	—	—	—	—	82	100	100
										B	X	—	—	—	—	84	100	100
			—	—	X	91	100	5	2	A	X	—	—	—	—	60	95	88
			—	—	—	41	100	97	—	B	X	—	—	—	—	80	100	100
										D	A	—	X	X	—	—	86	100	99
3.0/-TC—3	0	3	—	—	X	92	100	6	1	A	—	X	X	—	—	89	100	91
			—	—	X	97	100	0	—	B	—	X	X	—	—	47	94	78
			—	—	X	89	100	0	2	A	—	X	—	—	X	88	100	6
			—	—	—	—	—	—	—	B	X	—	—	—	—	93	100	90
										C	X	—	—	—	—	86	98	100
									3	A	—	X	—	—	X	88	100	4
										B	—	X	—	—	X	80	100	78
Other engine families									No data									

Table II-3.—*Volkswagen*

[0.41 HC, 3.4 CO, 1.0 NO_x]

Engine family and number of vehicles	W/O factors					W/factor applied			
	Vehicles P/F		Reasons for failures		Probability	Vehicle	Factor	Vehicles P/F	Reason for failures	Probability
2.0/						No data				
1.6/						No data				
1.6/-TC						No data				

Table II-4.—*Peugeot*

[0.41 HC, 3.4 CO, 1.0 NO_x]

Engine family and number of vehicles	W/O factors					W/factor applied			
	Vehicles P/F		Reasons for failures		Probability	Vehicle	Factor	Vehicles P/F	Reason for failures	Probability
2.3/-TC						No data				
XD3S						No data				

Table II-5.—*Volvo*

[0.41 HC, 3.4 CO, 1.0 NO_x]

Engine family and number of vehicles	W/O factors								W/factor applied									
	Vehicles P/F		Reasons for failures			Probability			Vehicle	Factor	Vehicles P/F		Reason for failures			Probability		
	P	F	HC	CO	NO_x	HC	CO	NO_x			P	F	HC	CO	NO_x	HC	CO	NO_x
2.4/—1	—	1	—	—	X	88	100	0	1	A	—	X	—	—	X	86	100	0
2.4/-TC									No data									
2.0/									No data									

III. Statistical Treatment of the Data

No basic changes have been made in the Monte Carlo methodology since its last use in a technical appendix. The Monte Carlo methodology has been discussed in three previous technical appendices. These appendices are:

1. Appendix B, Technical Appendix to the Decision of the Administrator in Remand of the United States Court of Appeals for the District of Columbia Circuit, April 11, 1973.

2. Appendix A, Technical Appendix to the Decision of the Administrator in re: Applications for Suspension of the 1976 Motor Vehicle Exhaust Emission Standards, July 30, 1973.

3. Appendix A, Technical Appendix to the Decision of the Administrator in re: Applications for Suspension of the 1977 Motor Vehicle Exhaust Emission Standards, March 5, 1975.

IV. Diesel Engine Variability Update for Monte Carlo

The basic statistical analyses performed by EPA's Monte Carlo procedure were not altered, however, the prior Monte Carlo procedure did not contain deteroriation factor (DF), car-to-car, or test-to-test variabilities for Diesel powered vehicles. Consequently, these Diesel powered vehicle variabilities were obtained by analysis of the data submitted by the applicants, data obtained from the California assembly line test programs, and the Selective Enforcement Audit (SEA) data available to EPA. The following discussion summarizes the variabilities utilized in to the Part I (look-up tables) of the Monte Carlo procedure.

Test-to-Test Variability

Test-to-Test variability refers to the repeatability of a vehicle when tested under FTP conditions several times. Since vehicles will not repeat exactly each time they are tested, the variability of these vehicles must be ascertained and factored into the total variability of the Monte Carlo procedure. Table IV–1 lists the test-to-test variability determined for each of the applicants by analysis of the referenced data.

Car-to-Car Variability

In addition to test-to-test variability, the test results from nominally identical vehicles constructed to the same specifications exhibits a car-to-car variability. This information was gleaned from the applicant's submissions and augmented with data from either the State of California end-of-line audit data or EPA monitoring of SEA data. Representative car-to-car variabilities are detailed in Table IV–2.

Table IV–1.—*Sigma Test to Test for Applicants*

Manufacturer	HC	CO	NO_x
GM [1]	0.029	.039	.030
VW	No data supplied		
Daimler-Benz [2]	.026	.091	.080
Peugeot [3]	.044	.232	.022
Volvo [4]	.039	.117	.041
Input σ_{t-t}	.037	.119	.041

[1] (4 at attachment 2).
[2] (5 at Tabs 2 and 3).
[3] (7 at 2–17, 2–22, 2–23).
[4] (6 at 2–20, 2–23).

The car-to-car variability has been modified by the removal of the test-to-test variability thereby not double accounting the test-to-test variability.

Table IV–2.—*Sigma Car-to-Car for Applicants*

Manufacturer	HC	CO	NO_x
GM [1]	0.345	0.165	0.159
VW [2]	.128	.169	.077
Daimler-Benz [3]	.149	.171	.152
Peugeot	No data supplied		
Volvo [4]	.166	.478	.506
$\sigma_{c-c+t-t}$	.197	.245	.174
Input σ_{c-c} [5]	.194	.214	.171

[1] (4 at Attachment 4).
[2] (8 at Attachment and 4).
[3] (6 at Attachments 2, 9 at 1).
[4] (10 at 2–28, 29, 30).
[5] (adjusted for σ_{t-t}).

DF Variability

In addition to test-to-test and car-to-car variabilities, the Monte Carlo procedure also needs the deterioration factor variability entered. These variabilities indicate the DF variability exhibited by nominally identical vehicles as the applicants attempt to achieve the durability mileage accumlation needed to demonstrate compliance with the emission standards. These deterioration factor variables also include test-to-test variability which have been removed from the DF variabilities listed in Table IV–3.

Table IV–3.—*Sigma DF's for Applicants*

Manufacturer	HC	CO	NO_x
GM [1]	0.175	0.077	0.054
VW [1]	.099	.094	.034
Daimler-Benz [2]	.161	.085	178
Peugeot	No data submitted		
Volvo	No data submitted		
Mean σ_{DF+t-t}	.141	.085	.083
Input σ_{DF}	.137	.085	.076

[1] (1980 Preliminary Certification Data).
[2] (1980 Preliminary Certification Data and 6 at various unnumbered pages).
[3] (adjusted for σ_{t-t}).

V. Projected Technological Improvements (Factors)

The vehicle emission data included in the waiver applicant's submissions for EPA analyses are often obtained over durability mileage accumulation schedules without using the most advanced technology that could potentially be available to the manufacturer for certification in the 1981 model year. There are reasons why this occurred. First, such technology may not have been available in quantity when fleets of vehicles began mileage accumulation. Second, all vehicles submitted for EPA staff analysis may not have been specifically designed for the 1981 and post-1981 Federal emission standards. Thirdly, technology may not appear on durability vehicles because the manufacturers have made a decision that the technology would be too costly for production vehicles, the lead time was not sufficient to implement the technology, the technology was too complex, etc.

Therefore, in order to account for some of the deficiencies in emission hardware, projected technological improvements (factors) have been applied to all of the emission durability vehicles submitted by the manufacturers. Due to substantial lead time problem for implementation of new or additional technology by the 1981 model year, these factors have been applied only for currently known

hardware that can be implemented in 1981 certification and production. These improvements have been basically limited to advanced Exhaust Gas Recirculation (EGR) systems, injection timing modifications, water injection, fuel additives, air pump addition and inertia weight reductions.

The factors that have been applied to the data are dimensionless numbers representing the improvement in emission performance that is predicted for the more effective emission control technology. The factors are derived from data that reflect the emission performance of a vehicle with and without the more effective technology. For example, a factor for NO_x of 0.90 indicates that a ten percent reduction in NO_x is projected for the use of the more effective technology.

Other factors which were developed, but not used in the following analysis include factors for:

- EGR valve replacement
- Injection pump recalibration
- Air intake throttling
- Insulated prechambers
- Water Injection—Oxidation Catalyst

It should be noted that because of the paucity of data submitted by the applicants, other factors could not be obtained. The technical analysis therefore was limited by this lack of data. Durability vehicle data for Monte Carlo simulation, and prototype emissions data vehicle results for technological improvement evaluations were, in many cases, minimal.

General Motors Timing Factor for Throttle Angle Controlled EGR Equipped Vehicles

General Motors has been experimenting with an EGR system which has the EGR rate modulated by the position of the throttle. This system is projected to be the standard production hardware by model year 1981 (I at II–8).*

While this EGR system has been designed to reduce NO_x from the engine, further reductions in NO_x formation may be realized by retardation of the basic injection timing. Therefore, a search for this type of factor was undertaken.

General Motors supplied supplemental data for the record contained data which included the injection timing sensitively for an engine equipped with a throttle angle controlled EGR. (4 at Attachments 7 and 8).

*The brackets contain the description x at y. This means the reference is located in reference number x (listed at the end of this document) at page number y.

These data are reproduced in Table V–1. The data in Table V–1, indicated that in the case of vehicle number 99324, retardation of the injection timing produces a beneficial effect on NO_x formation up to −8° retard. However, after −2° retard, there is a detrimental effect on HC and CO. The opposite effect is noted on vehicle number 88514 which has no EGR. Advancement of injection timing on VIN 88514 caused a HC and CO reduction with a corresponding increase in NO_x formation.

Table V–1.—*Timing Sensitivity Factors for 5.7l MFI—Throttle Angle Controlled EGR VIN 99324*

HC	CO	NO_x	Timing	MPG_u	MPG_h
(Factors in parentheses)					
.25	1.32	2.50	Baseline	20.0	30.1
.22	1.25	1.94	−2°	19.6	29.5
(.88)	(.95)	(.77)	.....	(.98)	(.98)
.32	1.34	1.81	−4°	18.8	28.7
(1.28)	(1.02)	(.72)	.....	(.94)	(.95)
.32	1.46	1.68	−5°	18.4	28.5
(1.28)	(1.10)	(.67)	.....	(.92)	(.95)
.68	1.95	1.49	−8°	18.0	27.4
(2.72)	(1.47)	(.60)	.....	(.90)	(.91)
5.7l wo/EGR–VIN 88514, 1980 Engine					
.64	1.4	1.31	1.6° (Base ?)		
.47	1.2	1.33	2.7°		
(.73)	(.86)	(1.01)	.....		
.45	1.2	1.42	3.7°		
(.70)	(.86)	(1.06)	.....		
.30	1.0	1.80	5.1°		
(.47)	(.71)	(1.37)	.....		

Since the changing of injection timing is considered a relatively minor technological change, the conservative factor for two degree injection timing retard was applied to three of the GM 5.7l vehicles, 3BN69, 85307, and 3N69N9MZ05983 simulated in the Monte Carlo analysis. This factor was selected because, (1) this technology has a short lead time and could be implemented in model year 1981; (2) low cost, and (3) minimal impact on fuel economy. These factors are for HC, CO, NO_x MPG_u, MPG_h respectively: 0.88, 0.95, 0.77, 0.98, 0.98. The later two factors indicate a reduction in fuel economy.

There are no estimates for the impact on particulates for this technology. The reason for this is there were no corresponding particulate data given for either of the vehicles, (99324 or 88514) that were used to generate the factor.

GM Inertia Weight Reduction Factors

General Motors repeatedly claimed that the denial of the NO_x waiver would preclude, or at least jepordize the production of "family size" cars (4 at 8). Questioning by EPA at the NO_x waiver hearings probed the impact of lowering inertia weight on the regulated exhaust emission levels. General Motors supplied data on two vehicles in the 4500 pound inertia weight class from which the technological improvements on exhaust emission levels could be ascertained. These data are given in Table V–2 and are from (4 at Attachment 12).

Table V–2.—*Inertia Weight Factors for General Motor 5.7l Engine Family*

	HC	CO	NO_x	Part	MPG_u	MPG_h	IW
VIN [illegible]—No EGR							
	.24	.99	1.93	.46	18.6	26.7	5500
	.24	.97	1.86	.35	20.0	[illegible]	4500
55/45 Factor	(1.00)	(.98)	(.96)	(.76)	(1.07)	(1.00)	.....
	.25	.91	1.80	.30	21.2	27.4	5000
55/35 Factor	(1.04)	(.91)	(.93)	(.65)	(1.13)	(1.02)	.....
45/35 Factor	(1.04)	(.94)	(.96)	(.85)	(1.06)	(1.02)	.....
VIN 78504							
	.78	1.60	1.69	.31	17.9	.....	5500
	.76	1.53	1.55	.71	20.0	.....	4500
55/45 Factor	(.97)	(.95)	(.91)	(.87)	(1.11)	.....	.....
	.61	1.50	1.53	[illegible]	21.0	.....	3500
55/35 Factor	(.78)	(.93)	(.90)	(.80)	(1.17)	.....	.....
45/35 Factor	(.80)	(.98)	(.98)	(.91)	(1.05)	.....	.....
Average factor	(.92)	(.96)	(.97)	(.34)	(1.03)	(1.02)	.....

The average factor was applied to all four 5.7l powered vehicles simulated in the Monte Carlo. The average factor is considered by the EPA technical staff as a conservative factor with a positive improvement on fuel economy and particulates.

Because of the lead time necessary for the introduction of redesigned, more efficient vehicles, the application of this factor is not considered applicable for all GM 5.7l vehicles for model year 1981 and possibly (although not to the extent for MY81) for model year 1982 as well,

in the technical staff's opinion. The post 1982 time frame may be a target year by which the 5.7*l* powered vehicles could be reduced to 3500 pound inertia weight. (18 at 5–2, Figure 5.2)

Fuel Modification Factors

In an attempt to ascertain the effects of fuel modifications on exhaust emissions and particulates, GM investigated over thirty additives and combinations of additives, fuel blends and water injection. These types of fuel modifications have the potential for both a reduction in NO_x and particulates.

The EPA technical staff feels that fuel additives, if successful, could be applicable in model year 1981. Fuel blending changes are longer lead items which impact not only the vehicle manufacturers, but also the fuel producers and fuel distribution systems.

Water injection is also a longer lead item and questions of engine durability, corrosion, freezing, owner compliance in refilling water container, etc., need to be addressed and answered. Answers to these questions indicate a lead time in the post 1982 model year. Because of these uncertainties, EPA technical staff picked conservative factors for application in the Monte Carlo simulation.

Table V–4 details the data general from the General Motors application for NO_x waiver (1 at Figure II.C.32)

As noted in Table V–3, the fuel blend has potential for a ten percent reduction in NO_x with a potential for twenty-seven percent reduction in particulate and a modest fuel economy impact. Additives, on the other hand, have a modest five percent NO_x benefits, seventeen percent particulate benefit, and a two percent benefit on fuel economy.

These factors were applied to the vehicle numbered 85307 in the Monte Carlo Simulation.

There may be difficulties with lead time, owner compliance, corrosion, freezing etc., which detract from the application of these technologies in the near term.

Table V–3.—Fuel Modifications Factors

Type of test	Fuel used	Emissions g/m				Economy City MPG	Tests
		Part	HC	CO	NO_x		
Fuel blends:							
Car 68425	D–2 baseline	0.667	0.475	1.62	1.67	19.83	2
5.7*l*	E–5 fuel blend	.487	.453	1.49	1.51	19.32	3
	(Factors)	(.73)	(.94)	(.92)	(.90)	(.97)	
Additives:							
Car 68425	D–2 Baseline	.789	.488	1.61	1.75	19.11	3
5.7*l*	D–2+Y–4 additive	.657	.463	1.61	1.66	19.51	2
	(Factors)	(.83)	(.99)	(1.0)	(.95)	(1.02)	
Emulsions:							
Car ES67604	D–2 baseline	.219	.419	1.04	1.05	38.9	2
1.5*l*	D–2+15% H_2O+surfactant	.205	.600	1.72	.972	37.2	2
	(Factors)	(.94)	(1.43)	(1.65)	(.93)	(.96)	

A factor was developed for the use of water plus a surfactant emulsion. The data for this factor can also be seen in Table V–3. EPA technical staff decided against using this factor for the General Motors vehicles in addition to the potential problems with water injection noted earlier because; (1) it was developed on a 1.5*l* engine and there are no indications that the factors would be numerically the same for either a 5.7*l* or 4.3*l* engine, and (2) the factor for HC would exacerbate the HC problem indicated in the data entered into the Monte Carlo simulation, thereby decreasing the probability of passing.

No EGR to EGR Factor for GM 5.7l Engine

An attempt was made to determine the impact of equipping a non-EGR vehicle with EGR and to assess the impact of this addition on total particulate emissions. Data for this factor were obtained from the GM submission. These data are reproduced in Table V–4.

These data indicates a positive effect on NO_x with negative effects on HC, CO and particulates, at least from the one vehicle which included particulate measurements in the submission.

This factor was applied to vehicle numbered 85307 in the Monte Carlo simulation.

Table V–4.—*No EGR to EGR Factor for GM 5.7l Engines*

Test No.	HC	CO	NO_x	MPG_e	Part.	Remarks
For Vehicle VIN 85307						
.....	0.40	1.2	1.65	21.0	.....	Baseline-VEL 50,091 miles.
.....	.55	1.4	1.27	21.1	.....	W/EGR 53K miles.
(Factors)	(1.28)	(1.17)	(.77)	(1.00)	.....	
After adjusting to 0.6 NO_x:5143	.52	2.06	.60	20.9	.....	W/EGR (unspecified).
(Factors)	(1.21)	(1.72)	(.38)	(.95)	.....	
For Vehicle VIN 94558						
Date	HC	CO	NO_x	MPG_e	Part.	Remarks
Jan. 9, 1979	0.36	1.72	0.79	20.5	0.60	W/EGR (assumed TAC–EGR).
Jan. 10, 1979	.30	1.79	.75	20.0	.65	
Jan. 22, 1979	.54	2.28	.82	19.8	.....	
Jan. 23, 1979	.41	1.88	.78	20.4	.....	
Avg	.30	1.92	.78	20.4	.65	
Jan. 12, 1979	.23	1.14	1.71	20.3	.31	W/O EGR.
Jan. 13, 1979	.28	1.13	1.71	20.9	.29	
Avg	.26	1.14	1.71	20.6	.30	
(Factors)	(1.50)	(1.68)	(.46)	(0.99)	(2.17)	

Increased EGR Factor for DB2.4l Engines

Daimler-Benz, like most of the other applicants, indicated that EGR was the most promising and viable approach to the reduction of Diesel NO_x emissions (5 at II–26). Daimler-Benz plans to introduce EGR systems in phases to allow for the accumulation of EGR use experience, refinement of EGR application, and evaluation of in-use durability problem (5 at II–21 thru II–27).

In order to predict the potential for the use of higher EGR rates, the EPA technical staff developed a factor for increased EGR. This factor was developed utilizing the data from vehicle W123D24–825 with Reverse Flow Damping Valves (RFDV) and with and without EGR application (5 at unnumbered page). These data are shown in Table V–5.

Table V–5.—*Increased EGR Factor 2.4l Engine*

Test No.	HC	CO	NO_x	MPG_e	
Baseline—No EGR					
56887...	0.173	1.11	1.70	25.1	
56893...	.134	1.08	1.68	24.1	
Avg...	.154	1.10	1.69	24.6	
EGR Added					
56951...	0.135	1.03	1.44	25.1	56898
57898...	.124	1.08	1.08	25.3	
56902...	.132	1.06	1.34	24.6	
Avg...	.130	1.05	1.28	25.0	
Increased EGR					
57645...	0.174	1.45	0.81	24.5	
57650...	.167	1.95	.80	24.5	
Avg...	.171	1.70	.81	24.5	
Factors	(.84)	(.95)	(.75)	(1.01)	EGR
	(1.11)	(1.54)	(.48)	(1.00)	Increased EGR.

The factors selected (1.11, 1.54, 0.48) apply pressure to hydrocarbons and carbon monoxide, but show benefit for reduction in NO_x. There is no particulate factor because no baseline particulate data supplied. Data for this engine indicated that at increased EGR levels for the 2.4*l* engine, the particulate levels will be approximately 0.52 gram/mile. (6 at Table 2) This level of particulate is an increase of thirty percent over the levels of particulate associated with EGR only (0.40 grams per mile) (6 at Table 2)

These factors were applied to vehicle numbered W123D24–213 in the Monte Carlo simulation.

Bosch A/F Ratio-Controlled EGR System Factor for 3.0l Engine

Daimler-Benz has experimented extensively with the Bosch Corporation EGR system. (5 at II–51 thru II–57) Daimler-Benz has halted further development of this system due to "some significant inherent short comings in the system". (5 at II–55)

Data were evaluated to establish the potential of this system. It is felt by the technical staff that this technology may be available for model year 1982, since considerable durability mileage and development effort has been expended by Daimler-Benz on the system already.

The factors were derived from vehicle VIN W123D30–94 equipped with a 3.0*l* Diesel engine. There were no particulate data supplied. These data are outlined in Table V–6. All vehicles equipped with a 3.0*l* NA engine in the Monte Carlo simulation had these factors applied to them.

Increased EGR Factor for 3.0l Engine

Similar to the factor developed for the 2.4*l* engines, the EPA technical staff developed increased EGR rate factors for the 3.0*l* engine. These data are shown in Table V–7 and are from vehicle W123D30–826. (6 at Table 2) These factors were applied to vehicles numbered W123D30Z002 and W123D30–287 in the Monte Carlo simulation.

The particulate data presented indicates a factor of 2.1 based on two tests which range from 0.55 to 0.70 gram per mile. The EPA staff concludes the use of technology represented by this factor could place upward pressure on particulates.

Table V–6.—*Bosch A/F Ratio-Controlled EGR System Factor*

Test No.	HC	CO	NO_x	MPG
54750 w/o EGR	.272	1.32	1.67	24.6
55037 w/o EGR	.272	1.23	1.59	25.3
55059 w/o EGR	.246	1.20	1.60	25.3
57636 w/EGR	.275	1.17	0.86	23.7
57625	.277	1.17	0.87	25.0
	.276	1.17	0.86	24.7
(Factors)	(1.04)	(.92)	(.49)	(1.02)

Table V–7.—*Increased EGR on 300D Factor*

Test No.	HC	CO	NO_x	MPG
56237	.235	1.13	1.29	25.2
56324	.242	1.14	1.26	25.3
56326	.234	1.10	1.31	25.7
	.237	1.12	1.29	25.7
56968 w/EGR	.207	1.03	1.35	25.5
57710	.218	1.03	1.28	25.9
	.212	1.03	1.32	25.7
(Factors)	(.89)	(.92)	(1.02)	(1.01)
57773 w/Increased EGR	.250	2.23	0.81	25.9
57778	.234	1.81	0.83	25.6
	.242	2.02	0.82	25.7
(Factors)	(1.02)	(1.80)	(.63)	(1.01)

Factors for EGR and Increased EGR Rate for Turbocharged 3.0l Daimler-Benz Engines

To assess the effect of EGR on the turbocharged 3.0/ Daimler-Benz engines, Daimler-Benz ran a series of tests both with and without EGR on prototype vehicles and engines. These results were described in various locations in the Daimer-Benz application for a NO_x waiver. The EPA technical staff considered these data to evaluate and perhaps develop a series of factors that could be applied to the Monte Carlo simulation vehicles which had turbocharged engines. These data are in Table V–8 which were described in references 5 and 6 at various unnumbered pages.

As noted in Table V–8, it was difficult to determine the exact emission levels, both with and without EGR, from the turbocharged Daimler-Benz engines. The approach taken was to first determine the basic emission levels from the

Table V–8.—*EGR Factors for Turbocharged Engines*

	Miles	HC	CO	NO_x	MPG	Test No.
Low Mileage Vehicles—Different Engines—w/o EGR VIN W116 D30A–214						
Engine No.:						
EA 02–135	7,703	0.084	0.50	1.61	24.9	10288
EA 02–153	8,947	.090	.06	1.66	24.0	10805
EA 02–159	?	.195	.04	1.69	22.9	54726
EA 79–098	?	.093	.05	1.57	24.5	10267
Average		.143	.04	1.63	23.9	
Different Engines—w/EGR—VIN W116 D30A–219						
Engine No.:						
EA 80–100	?	.100	.946	0.98	25.3	9256
EA 80–100	?	.120	.944	1.09	23.9	9260
Average		.110	.945	1.04	25.1	
Engine No.:						
EA 80–139	?	.336	1.14	1.27	24.1	10681
EA 80–139	?	.278	1.10	1.37	23.0	10686
EA 80–139	?	.323	1.03	1.32	23.7	
Average		.313	1.10	1.32	23.6	
VIN W 116 D30A–815 w/EGR—Same Engine/Vehicle Combination						
Test No.:						
55868	1,540	.112	.86	1.22	24.7	
55922	1,518	.125	.92	1.36	24.7	
55931	1,585	.109	.89	1.25	25.0	
Average		.115	.80	1.27	24.8	
Test No.:						
56231	1,650	.113	.91	1.18	24.8	
56236	1,665	.140	.86	1.208	25.4	
56322	1,680	.108	.85	1.21	25.7	
Average		.120	.87	1.19	25.2	
Improved EGR System						
Test No.:						
56955	1,720	.138	1.47	.94	23.6	
56963	1,736	.241	1.79	.66	23.6	
56969	1,754	.213	2.25	.92	23.6	
57017	1,778	.302	2.29	.86	23.9	
Average		.198	2.07	.90	23.8	

Developed Factors

	HC	CO	NO_x	MPG	Comment
	0.143	0.84	1.63	23.9	w/o EGR, Baseline, different engines.
	.313	1.10	1.32	23.6	w/EGR, different engines.
(Factors)	(2.18)	(1.31)	(.81)	(0.99)	
	.143	0.84	1.63	23.9	w/o EGR, Baseline, different engines.
	.120	0.87	1.19	25.2	w/EGR, same engine/vehicle comb.
(Factors)	(.84)	(1.03)	(.73)	(1.05)	
	.143	0.84	1.63	23.9	w/o EGR, Baseline, different engines.
	.198	2.07	.90	23.8	w/Improved EGR, same engine/vehicle comb.
(Factors)	(1.38)	(2.46)	(.55)	(1.00)	
	.115	0.09	1.27	24.8	w/EGR, same engine/vehicle comb.
	.198	2.07	.90	23.8	w/Improved EGR, same engine/vehicle comb.
(Factors)	(1.72)	(2.32)	(.71)	(.95)	

turbocharged 3.0/ engine without EGR. The low mileage/different engine data at the top of Table V–8 established these levels. The same was done for turbocharged engine equipped with EGR, the middle portion of the table. Next, an attempt to determine the emission levels from a single vehicle multiple tests was made. The emission levels from vehicle VIN W116D30A–815 with EGR and what Daimler-Benz calls improved EGR were tabulated and comprise the bottom portion of the Table.

The factor for improved EGR for both a vehicle equipped with and without EGR and a factor for EGR for a vehicle without EGR were developed from these data.

The factor for the application of EGR to a turbocharged vehicle without EGR was applied to vehicles VIN W116D30A–814 and W116 D30–215 in the Monte Carlo simulation.

The factor for improved EGR to a turbocharged vehicle without EGR was applied to vehicle the same two vehicles.

The factor for improved EGR to a turbocharged vehicle with EGR was applied to vehicles VIN W116D30A–149 and W123 D30–287 in the Monte Carlo simulation.

These factors were applied to simulate the potential EGR would have in reduction of vehicle NO_x emissions. These use of EGR is considered a technological reality and the optimization of EGR rates "improved EGR", is considered to be achieveable by model year 1981. The questions of engine durability and impact on oil change intervals remain to be answered. (11 at 35)

The particulate levels associated with EGR and increased EGR factors utilized on the turbocharged engine are derived from vehicle W116D30A–815 (6 at Table 2). For vehicle equipped with EGR, Daimler-Benz reports particulate levels of 0.47 grams per mile. For increased EGR, the particulate levels are 1.02 grams per mile. There are no particulate levels for a no-EGR vehicle available. Therefore, it is impossible to determine the effect of EGR on particulate for these factors. However, going from EGR to increased EGR will put upward pressure on particulates.

Factor for Water Injection

Daimler-Benz reported the following:

Daimler-Benz is doing extensive work in the field of modifying and refining existing and improved Diesel technology towards the target of 1.0 g/m NO_x in order to meet the statutory NO_x standard as soon as possible and eliminate the need for a waiver by at least one model year.

At the same time, a special department within Diamler-Benz is working on advanced Diesel technologies which will not be ready for production during the waiver years but might show the potential of further reducing NO_x values down to the research target of 0.4g/m. (15 at II–57)

Data were described which allowed the EPA technical staff to develop factors which could evaluate the potential for these technologies. Because these technologies are not optimized as yet, they may not be applicable to model year 1981. These data are presented in Table V–9.

The first factor developed was for a 2.0/ engine equipped with fuel injection, simplified EGR system, water injection, and an oxidation catalyst. The factors developed are clouded by the use of nonheated lines to the Flame Ionization Detector (FID). This fact prevents a true evaluation of the hydrocarbon performance of the system. There is a reduction in NO_x and CO and an increase in fuel economy. There were no particulate data submitted for this technology. This factor was *not* applied to any of the vehicles in the Monte Carlo simulation because the technical staff had no way of assessing if and when this technology, developed on a 2.0/ engine, could be translated to any of the DB engines for which waivers are sought.

Table V–9.—*Advanced Technologies Factors (5 at II–58–75)*

Description	HC [1]	CO	NO_x	MPG_c	MPG_b
DFI–EGR–WI–OC Factor—2300 Vehicle					
Wo/system	0.04	1.21	1.42	30.5	33.0
W/system	0.18	.58	0.34	31.6	33.8
Factors	(2.14)	(.48)	(.24)	(1.04)	(1.02)
DFI–EGR–WI–TC Factor—3000S					
Wo/system	.064	.75	1.49	28.0	32.1
Phase I	.133	2.19	.49	28.3	
Phase II	.022	1.95		28.3	
Phase III	.156	1.90			32.9
Factors:					
Phase I	2.07	2.30	.33	1.01	
Phase II			.24	1.01	
Phase III	2.43		.19	1.07	
DFI–EGR–CWI Factor—240D					
Wo/system	.08	0.78	.89	29.9	33.3
W/system	.34	2.66	.36	27.9	30.7
Factors	(4.36)	(3.41)	(.41)	(.93)	(.92

[1] Nonheated lines to FID.

Volvo Timing Retard Factor

Volkswagen and Volvo are mutually developing a 2.4/, 6 cylinder Diesel engine for a 3500 IW vehicle (10 at 1–4). While Volvo presented no data to determine a timing retard factor for their applicant engines, Volkswagen reported data on a 2.4/, 6 cylinder engine with 2°, and 2½° injection retard (8 at Attachment 7).

These data indicated HC factors of .98 for 2° retard and 1.06 for 2½° retard, and no CO values, plus NO_x factors of .81 for 2° retard and .76 for 2½° retard. The technical staff assigned a 1.0 factor for CO as retarded timing usually doesn't substantially affect CO emission levels. Both injection timing changes placed upward pressure on particulates with factors of 1.07 and 1.13 respectively. The factors simulated were for 2½° retard, or factors of 1.06, 1.00, .76. The one Volvo vehicle in the Monte Carlo simulation received this factor.

Summary

A summary of the factors applied to the vehicles simulated in the Monte Carlo analysis are listed in Table V–10.

Table V–10.—*Key to Factors Applied to Vehicles in Monte Carlo Simulation*

	Vehicle	Factor	HC	CO	NO_x	Description
General Motors: 5.7/	4	A			0.77	Timing, TAC, EGR.
	[86307]	B	.92			AM factor 45/35.
		C				Fuel blend.
		D	1.21	1.72	.38	No EGR to EGR, wo/part.
		E			.46	No EGR to EGR, w/part.
Daimler-Benz:						
2.4/	1	A	1.11	1.54		Increased EGR.
	(W123D24–213)					
3.0/	1	A	1.04		.49	Bosch EGR system.
	[W123D30–287]	B	1.72	2.32	.71	Improved EGR from TC engine.
	2	A	1.02			Increased EGR.
	[W123D30–256]	B	1.64		.49	Bosch EGR system.
	3	A	1.04		.49	Bosch EGR system.
	[W123D30–255]					
3.0/-TC	1	A	1.72		.71	Improved EGR, w/ EGR.
	[W116D30A–149]	B	2.07			DFI–EGR–WI–TC.
	2	A	.94	1.03	.73	EGR for w/o EGR.
	(W116D30A–814)	B				Improved EGR.
		C	2.07			DFI–EGR–WI–TC.
	3	A		1.03	.73	EGR for w/o EGR.
	(W116D30A–215)	B			.55	Improved, EGR.
Volvo: 2.4/	1	A	1.06	1.06	.76	Timing retard.
	(80-4)					

VI. Discussion of Individual Manufacturer's Technical Capability

Discussed in this section are all the vehicles which, (1) were submitted by each of the five applicants, and (2) were also acceptable for input into the Monte Carlo simulation. Additionally, acceptability for input means. (1) that the vehicle is a durability vehicle which has accumulated a minimum of 20,000 miles with the same major emission control components, and (2) that a minimum of four valid 1975 FTP tests have been conducted on the vehicle.

A discussion of the pass/fail determinations noted in Section II are also presented in this section. To pass the 1981 emission standards of 0.41 HC, 3.4 CO, 1.0 NO_x, the probabilities of passing each individual pollutant *must* be greater than or equal to 80%. If the probability of passing HC, for example, is less than or equal to 79%, the vehicle fails—*even if the probabilities for CO and NO_x* greatly exceed the 80% cutpoint.

Pass/fail analysis is provided only for emission standards for 0.41 HC, 3.4 CO, and 1.0 NO_x. The complete data needed for a similar analysis in emission standards of 0.41 HC, 3.4 CO, 1.5 NO_x are presented in the attached Monte Carlo outputs. An analysis of a NO_x standard between 1.0 gpm and 1.5 gpm are included in the discussion of the vehicles entered into the Monte Carlo simulation where appropriate.

A. General Motors

The vehicles contained in the General Motors NO_x waiver application (References 1 and 4) which met the minimum criteria for entry into the Monte Carlo simulation are shown in Table VI–1. Only one out of the twenty (5%) of the vehicles sumbitted met the minumum requirements for simulation.

Additionally, the data that were analyzed generally indicated difficulty in achieving the 1981 HC standard and thereby may have predestined the failure to achieve a passing probability in the Monte Carlo simulation. This fact may obsure the applicant's capabilities to achieve the requisite NO_x levels and makes a decision on interim levels between 1.5 and 1.0 g/mile NO_x difficult.

Table VI–1.—*Vehicles in General Motors Waiver Application Meeting the Minimum Criteria for Entry into Monte Carlo*

Engine family	VIN	Entered in Monte Carlo	If not entered—why*
4.3/.....	94541	No	A
	94546**	No	B
	[3J08PWM80947]		
	94547	No	A
	94399**	No	B
	[1N47P9M497260]		
	94305	No	A
	94514	No	A
	94515	No	A
	94704	No	A
5.7/.....	96612	No	A
	96604**	No	B
	[3X60U0MZ30735]		
	99585	No	A
	99636**	No	B
	[3N60N0MZ05980]		
	96637**	No	B
	[3BN68]		
	86634	No	A
		86597	
		No	A
	85307	Yes	
	89601	No	A
	86633	No	A
	89600	No	A
	87363	No	A

*Reason for not entered—
A—Does not meet minimum requirement of 20,000 miles, four valid data points.
B—Data submitted by applicant insufficient to enter into Monte Carlo simulation—EPA technical staff would have had to supplement the data with 1980 Certification data from vehicle identified in brackets. Technical staff believes vehicles are indentical, dissimilar in VIN only.

Pass/Fail Analysis for 5.7l Engines

The prototype vehicle entered into the Monte Carlo simulation which was powered by the applicant's 5.7*l* engine *failed* the Monte Carlo analysis at 1.0 g/mile NO_x both with and without factors. In none of the cases simulated did the application of factors allow this engine to pass the 1.0 g/mile NO_x.

A discussion of the vehicle follows.

Vehicle, VIN 85307, represents the 1980 combustion chamber and roller cam lifters which the applicant plans to utilize in the 5.7*l* engine. Table VI–2 details the results of the Monte Carlo simulation at the 1.0 g/mile NO_x standard.

Table VI–2.—*Percent Probability of Passing 1.0 NO_x Standard*

Description	HC	CO	NO_x
Without factors.....	11	100	0
Factor A.....	49	100	0
Factor B.....	38	100	0
Factor C.....	36	100	0
Factor D.....	15	100	100
Factor E.....	2	100	95

Analysis at interim levels were reviewed and it revealed this vehicle also would not achieve inteim levels between1.0 and 1.5 g/mile NO_x. The vehicle also fails HC standard for all cases.

The above vehicle is illustrative of the applicant's progress towards meeting a NO_x level of 1.0 g/mile.

Pass/Fail Analysis for Other Engine Families

General Motors requested a NO_x waiver for other engine families, the details which they wish to have remain confidential. [4 at I–4, I–9] General Motors did not submit acceptable durability data for these engine families and hence these engine families are considered "no data" engine families. No analysis were attempted for these engine families.

B. Daimler-Benz

The Daimler-Benz applications (References 5 and 6) contained the vehicles which meet the minimum requirement for entry into the Monte Carlo analysis. These are listed in Table VI–3.

Of the eleven vehicles submitted, seven vehicles were selected for inclusion in the Monte Carlo analysis.

Table VI–3.—*Vehicles in Daimler-Benz Waiver Application Meeting the Minimum Criteria for Entry in Monte Carlo*

Engine family	VIN	Entered in Monte Carlo	If not entered-why*
2.4/.....	W123D24-288	No	A
	W123D24-213	Yes	
	W123D24-289	No	B
3.0/.....	W123D30-286	Yes	
	W123D30-214	No	B**
	W123D30-255	Yes	
	W123D30-287	Yes	
3.0/—TC....	W116D30A-814	Yes	
	W116D30A-215	Yes	
	W116D30A-214	No	A
	W116D30A-149	Yes	

*Reason for not entered—
A—Does not meet minimum requirement of 20,000 miles, four valid date points
B—Excessive system modification over durability testing
**1980 Experimental California MY80 EGR system, went 100,000 miles but continual system modification throughout, plus possible DB lab-to-lab test correlation differences precluded the use of this data.

Pass/Fail Analysis for 2.4l Engines

The prototype vehicle simulated in the monte Carlo analysis failed the NO_x standards of 1.0 gram/mile. When a technological improvement of increased EGR was applied to this vehicle, the vehicle was projected to pass the 1.0 gram/mile NO_x standard. This engine family is projected to pass with an increased EGR factor. The supporting data can be found in Table VI–4.

Therefore, the EPA technical staff concludes from the Monte Carlo simulation that this engine family will pass the 1.0 gram/mile NO_x standard with increased EGR.

With respect to an interim standard, the 2.4*l* engine *cannot* pass any interim standard up to and including 1.5 gram per mile NO_x without the addition of a factor. Since this vehicle was equipped with some unspecified EGR rate, it was assumed by the technical staff this EGR rate was equivalent to the 1.5 NO_x concept EGR rate described in the DB application. (5 at II–21) The particulate levels associated with this concept is 0.04 grams per mile. Therefore, the application of increased EGR will put upward pressure on particulate levels.

Table VI–4.—*Percent Probability of Passing 1.0 NO_x Std*

Description	HC	CO	NO_x
W116D24-215			
Without Factors	97	100	0
Factor A	94	100	99

Pass/Fail Analysis for 3.0l Engines

Of the three vehicles simulated that are equipped with the 3.0*l* naturally aspirated engine, all three failed, without factors. When the factors of increased or improved EGR system and the addition of the Bosch EGR system factors were simulated two of the three vehicles passed the 1.0 gram/mile NO_x standard. The other one failed because the HC probability was below 80%. The EPA technical staff concludes that the increased rate or improved EGR system is probably implementable by model year 1981 and the Bosch system by model year 1982. Therefore, this engine family is considered to have passed when only NO_x is considered, the 1.0 gram/mile NO_x standard with the factors of increased or improved EGR system or the Bosch EGR system factors. The particulate levels at 1.0 gram per mile NO_x are in the range of 0.55 to 0.70 gram per mile. the particulate levels at 1.5 gram per mile NO_x are in the range of 0.26 to 0.34 gram per mile. (6 at Table 2) Daimler-Benz supplied no data on a 3.0*l* equipped vehicle without EGR, but EPA data for a 1979 certification vehicle at 2.0 gram per mile NO_x was 0.83 grams per mile total particulate. The EPA technical staff concludes that going from 1.5 to 1.0 gram per mile NO_x will probably tend to put upward pressure on particulate levels. (6 at Table 2) The data concerning these vehicles are displayed in Table VI–5.

Discussion of the individual vehicles follows.

Vehicle number W123D30–286 was equipped with reverse flow damping valves and EGR. Added to the vehicle simulation were factors for increased EGR and the Bosch EGR system. With these two additions, this vehicle was projected to pass the 1.0 gram/mile NO_x standard.

Table VI–5.—*Percent Probability of Passing 1.0 gram/mile NO_x Std.*

Description	HC	CO	NO_x
W123D30–286			
Without Factors	81	100	5
Factor A	80	95	[illegible]
Factor B	80	100	100
W123D30–255			
Without Factors	41	100	92
Factor A	36	100	[illegible]
W123D30–287			
Without Factors	84	100	71
Factor A	82	100	100
Factor B	84	100	100

However, Daimler-Benz indicated there were difficulties with the Bosch system which could increase the lead time necessary for adoption of the system (5 at II–55). None of the objections to the system appear to be insurmountable and could be overcome in or by model year 1982.

The use of increased amounts of EGR appear to be Daimler-Benz's approach to achieve 1.0 gram/mile NO_x levels and appears to be consistent with the Daimler-Benz application (5 at II–10 and II–45).

The second vehicle, W123D30–255, was a durability vehicle which met the minimum requirements for inclusion in the Monte Carlo simulation but was caveated with the notation that the mileage was not accumulated under EPA conditions [6 at Tab 3]. The technical staff was not convinced that the vehicle had not received "increase" EGR system manipulation during the mileage accumulation, hence the high HC levels. This vehicle could not achieve any interim standards nor the 1.0 gram/mile NO_x standard because of its low HC probability.

The remaining vehicle, W123D30–287 was factored with improved EGR (i.e. increased EGR rates and the Bosch EGR system factors), plus No EGR to EGR factor. These factors allowed this vehicle to achieve the 1.0 gram/mile NO_x standard.

Summary—2.4l and 3.0l Technical Capability

Daimler-Benz discussed at length durability problems, both with *engines* that use high rates of EGR, and with the various EGR *systems* during the NO_x waiver hearings (11 at 15, 16, 81–87, 94–95, and 107). Unfortunately, the discussions are somewhat confused in the record by the several different EGR *systems*, with the possibility for more than one EGR *rate* for each system were under discussion. EPA technical staff have assumed that the basic difference between different EGR systems is the *rate* of EGR. It was further assumed that the system which is experiencing the durability problem or potentially causing engine durability problems was the EGR II system with an unspecified EGR rate higher than the EGR I rate. The improved NO_x performance discussed above in the Monte Carlo analysis was based on the use of increased or improved EGR.

However, the issue raised by DB concerning EGR system durability and/or engine durability concerns was for a high EGR rate system, the same one used by EPA to forecast low NO_x performance. (It is assumed that any durability problems with the EGR I system are much less, since DB has certified such a system for 100,000 miles for California).

This durability issue is one for which there is not much data. DB expressed concern over this issue, and their concerns were part of the reason why they requested a waiver, to allow more lead time to (1) become more familiar with the in-use performance of EGR—equipped Diesels (e.g. the 1980 EGR I system) and (2) perform the necessary development and durability testing to enable DB to resolve any durability problems that might show up with the higher EGR rates.

Because of the uncertainty of the EGR system durability and/or engine durability with high EGR rates the EPA technical staff concludes that the technology represented by the increased or improved EGR factors is not yet available. The time available to DB to investigate and resolve any problems, if a waiver were to be granted, should allow the generation of the needed data to resolve the uncertainty that currently exists.

Pass/Fail Analysis for 3.0l-TC Engines

The analysis of this engine family was complicated by the system utilized on the vehicle simulated in the Monte Carlo analysis. Two of the vehicles, W116D30A–814 and W116D30A–215, were not equipped with an EGR system during the durability mileage accumulation. The other vehicle, W116D30A–149, was equipped with an EGR system. It was determined that the vehicles simulated with an EGR system are more representative of the systems Daimler-Benz plans to market in California in model year 1980. Daimler-Benz states. "In model year 1980 Daimler-Benz will introduce in California its limited EGR system for achieving a 1.5 NO_x standard in its 300D and 300SD models" (5 at II–21). Therefore, the two vehicles not equipped with EGR were not considered the prime system for analysis although

the data were included in the Monte Carlo simulation.

With the above comment, i.e. concentrating on the vehicle with EGR, the Monte Carlo simulation predicts that this engine family *fails* to achieve the 1.0 gram/mile NO_x standard with and without factors. This failure can be attributed to a failure to pass the *HC* standard of 0.41 gram/mile rather than the NO_x standard. This engine family is considered to have failed at the 1.0 gram per mile NO_x level by the technical staff.

These data are displayed in Table VI–6, and a discussion of the vehicles follows.

Vehicles numbered, W116D30A–814 and W116D30A–215, are not prime systems because they are not equipped with an EGR system. However, when simulated with an improved EGR system and an water injection factor, vehicle W116D30A–814 passed the Monte Carlo simulation at the 1.0 gram/mile NO_x standard. Vehicle numbered W116D30A–215 passed the 1.0 gram/mile NO_x standard with an improved EGR system factor.

The EPA technical staff considers this indicative of the *potential* for the 3.0*l*–TC engine family to eventually pass a 1.0 gram/mile NO_x standard when the advanced EGR system is developed for this engine family. Daimler-Benz stated that the development work on the prime system cannot be completed in time for model year 1981 (5 at II–22). Hence, depending on the Daimler-Benz experience in California at 1.0 gram/mile NO_x, in model year 1982, the potential for this system cannot be more accurately assessed until more data is amassed. Therefore, the conclusion that this engine family will fail is still valid due to failure to pass Monte Carlo and lack of lead time to install advanced EGR systems.

Vehicle W116D30A–149 was equipped with prototype EGR systems during the mileage accumulation runs. However, when simulated with an advanced or improved EGR factors, these vehicles failed. The failure was due to the inability to achieve the HC standard of 0.41 gram/mile HC. This in indicative of the pressure on hydrocarbon emission due to increased EGR rates and may be Daimler-Benz's basis for their conservative opinion on the advanced EGR systems potential (5 at II–22, 23).

There are no particulate data given by Daimler-Benz for a non-EGR turbocharged 3.0*l* engine. At the 1.5 gram per mile NO_x levels the total particulates range from 0.41 to 0.52 gram per mile. At 1.0 gram per mile NO_x, the particulate levels range from 0.96 to 1.07 gram per mile. There is upward pressure on particulates with use of increased EGR.

Table VI–6.—*Percent Probability of Passing 1.0 gram/mile NO_x Std*

Description	HC	CO	NO_x
W116D30A–149 (EGR)			
Without Factors	92	100	6
Factor A	88	100	91
Factor B	47	96	99
W116D30A–814 (No EGR)			
Without Factors	97	100	0
Factor A	98	100	0
Factor B	93	100	90
Factor C	86	98	100
W116D30A–215 (No EGR)			
Without Factors	00	100	0
Factor A	02	100	4
Factor B	80	100	78

Other Engine Families

Daimler-Benz alluded to two other engine families in a reply to Mr. Benjamin R. Jackson's letter of June 14, 1979, regarding additional data. (16 at 1) These two additional families are considered "no data" families because Daimler-Benz provided no durability vehicle data upon which an analysis could be made.

C. Volkswagen

Volkswagen has apparently not requested a waiver for their 1.5*l* engine. They have requested a waiver for their 1.6*l* and 1.6*l* turbocharged engine, but presented only limited development data for the 1.6*l* and 1.6*l* turbocharged engine families. Acceptable durability data, however, were presented for only the 1.5*l* engine.

The 1.5*l* engine cannot be used as a surrogate for the 1.6*l* engine in the opinion of the EPA technical staff, because the engines are different enough to have significantly different emission levels (13 at 81). The direction of the difference in emissions is not as important as the fact that there is a difference. However, the 1.6*l* engine appears to have higher emissions than the 1.5*l* engine and it is not considered appropriate to use the relatively good emission performance of the 1.5*l* engine to forecast the performance of the 1.6*l* engine.

Pass/Fail Analysis for 2.0l Engines

Volkswagen did not provide durability data for this engine family. This is considered a no-data engine family.

Pass/Fail Analysis for 1.6l Engines

Volkswagen did not provide durability data for this engine family. They did provide development vehicle data which was insufficient to meet the minimum qualifications for inclusion in the Monte Carlo simulation. This is considered a no data engine family.

Pass/Fail Analysis for 1.6l Turbocharged Engines

Volkswagen did not provide durability data for this engine family. This is also considered a no data engine family.

D. Peugeot

Peugeot has requested a waiver from the 1.0 gram/NO_x standard for model year 1981 through 1984 for engine families entitled XD2S and XD3S (14 at 22 and 7 at 1.3.1). The XD2S is their turbocharged version of the 2.3*l* naturally aspirated engine which they plan to market in 1980. The XD3S is a derivative of the XD2S engine. There is no mention of the naturally aspirated version being produced, or a request for a NO_x waiver beyond model year 1980.

The Peugeot application contained durability data for either the XD2S or XD3S engine family. These engine families are considered no data families.

Pass/Fail Analysis for 2.3l Turbocharged Engines

Peugeot provided no durability data for this engine family. It is considered a no data family.

Pass/Fail Analysis for XD3S Engines

Peugeot provided no durability data for this engine family. It is also considered a no data family.

E. Volvo

A.B. Volvo requested a NO_x waiver for three engine families. Their initial application called for a waiver for the 2.4*l* naturally aspirated engine and the 2.4*l* turbocharged engine (10 at 1–5). During the hearing proceeding, they amended their application to include a 2.0*l* five cylinder engine they may be able to purchase from Volkswagen (15 at 3).

Volvo supplied no acceptable durability data for either the 2.4*l* turbocharged or the 2.0*l* engines. These families are considered no data families.

A single durability vehicle was acceptable for Monte Carlo simulation (10 at 2–33).

Pass/Fail Analysis of the 2.4l Engines

The Monte Carlo simulation of vehicle number 80:4 indicates that the vehicle would fail, both with and without factors, at the 1.0 gram/mile NO_x standard. The probabilities of pass, without factors, for HC, CO, NO_x respectively are 88%, 100%, 0%. With an injection timing retardation factor of –2 ½°, the probabilities of passing at 1.0 gram/mile NO_x are 86%, 100%, 0% for HC, CO, NO_x.

This engine family is considered to fail at the 1.0 gram/mile NO_x standard.

Pass/Fail Analysis for 2.4l Turbocharged Engines

Volvo provided no durability data for this engine family. It is considered a no data family.

VII. Other Technological Considerations

Fuel Economy

Fuel economy is an important consideration in the statute and was emphasized in EPA'S guidelines. Two major issues can be identified (1) individual engine family fuel economy results or projections and (2) fleet sales weighted average fuel economy effects.

Individual Engine Family Fuel Economy Results

Only those engine families for which an emission control capability analysis was conducted are considered. Other, "no data" families are not considered.

Inclusion of all of the families discussed below does not imply that they have been determined to need a waiver. They are included because some of them are families for which an emission technological determination was made and therefore, the fuel economy performance is of interest.

There is general agreement that each engine family for which a waiver is granted must meet or exceed the applicable EPCA standards for the period for which the waiver is granted. This discussion is limited to those years for which it is also appropriate to forecast technology, i.e. for 1981 and 1982. The corresponding fuel economy standards are 22 and 24 miles per gallon.

Generally speaking, meeting 22 or 24 miles per gallon for a vehicle equipped with a Diesel engine is considered to be a straight forward task except for those vehicles which would be considered at the low end of the range of fuel economy capability. This low end of the capability could be due to many factors, state of engine development, vehicle weight etc., etc. Unfortunately, some of the engine families of some of the applicants (GM, DB) have tended in the past to fall near the bottom of the fuel economy performance spectrum for Diesels and require a further look.

The latest fuel economy results (as of 30 November, 1979) for all model year 1980 Diesel engine-equipped vehicles are shown below. Only the "composite" fuel economy results are shown. These values are the appropriate to compare to the 22 MPG and 24 MPG fuel economy standards for model years 1981 and 1982.

1980 Fuel Economy Results for Diesels

Manufacturer/model/displacement/transmission	MPG	MPG greater than 22 MPG?	MPG greater than 24 MPG?
VW/Dasher/90 CID/	41	Yes.....	Yes.
VW/Rabbit/90 CID/M4	45	Yes.....	Yes.
VW/Rabbit/90 CID/M5	47	Yes.....	Yes.
DB/240D/2.4/ /M4 (Cal.).....	30	Yes.....	Yes.
DB/240D/2.4/ /M4 (Cal.).....	27	Yes.....	Yes.
DB/300D/3.0/ /A4.....	25	Yes.....	Yes.
DB/300D/3.0/ /A4 (Cal.).....	26	Yes.....	Yes.
DB/300SD/3.0/ TC/A4.	27	Yes.....	Yes.
DB/300SD/3.0/ TC/A4 (Cal.).....	27	Yes.....	Yes.
DB/300TD/3.0/ /A4.....	25	Yes.....	Yes.
DB/300TD/3.0/ /A4 (Cal.).....	25	Yes.....	Yes.
GM/Eldorado/5.7l /A3.	24	Yes.....	Equal.
GM/Olds 88/5.7l /A3...	26	Yes.....	Yes.
GM/Olds 98/5.7l /A3...	24	Yes.....	Equal.
GM/Catalina /5.7l /A3.	26	Yes.....	Yes.
GM/Buick/5.7l /A3.....	24	Yes.....	Equal.
GM/Deville/5.7l /A3.....	24	Yes.....	Equal.

In the table above (Cal.) denotes a vehicle intended for the California market, which could also be a "50 States" vehicle.

All of the vehicles on the above table currently meet or exceed the fuel economy standards for 1981 and 1982.

It should be pointed out that the emission standards met by the above vehicles are 0.41 HC, 7.0 CO, 2.0 NO_x for 1980. These emission standards are not the same as the standards of 0.41 HC, 3.4 CO, 1.0 to 1.5 NO_x which are under consideration for the Diesel NO_x waiver. Therefore some discussion of any changes in fuel economy due to the different emission standards for 1981 or 1982 should be included. The only standard change of interest is the change in NO_x.

Because of the technological determinations made previously, the only standard change of interest is the change from 2.0 NO_x to 1.5 NO_x.

For Daimler-Benz all of their "Cal." vehicles exceed 24 MPG and also meet 1.5 NO_x for California certification. Therefore, all the DB engine families are projected to meet or exceed the 22 MPG and 24 MPG levels in 1981 and 1982.

For the GM 5.7*l* family the issue is complicated somewhat by the current lack of California certification fuel economy data at the 1.5 NO_x level. For 1981, all the 5.7*l* vehicles currently exceed the 22 MPG level by 2 to 4 MPG. It is expected that any changes from the 1980 vehicles to the 1981 vehicles would not cause the fuel economy to decrease to the extent that 22 MPG would not be achievable. For example Table V–1 indicates a 2% loss for timing change, Table V–2 indicates about a 2% gain for IW changes, and Table V–4 indicates both no change and losses in fuel economy. Considering this data together it is estimated that the change from 2.0 to 1.5 NO_x need not cause any reductions below 22 MPG for the 5.7*l* for 1981. Note especially the data in Table V–4, which show NO_x dropping from 1.65 NO_x to 1.27 NO_x with no negative fuel economy impact.

For 1982, some of the current 5.7*l* vehicles are right at the 24 MPG level and some exceed that level by 2 MPG. Even though the difference between the fuel economy standard level and the performance of the current vehicles is less than it is for 1981, it is still concluded that at the 1.5 NO_x level the fuel economy standard will be met or exceeded for 1982. This is because the changes to go from 2.0 NO_x to 1.5 NO_x have no or small fuel economy impacts, as discussed above, but more importantly, the extra year of development time available allows the possibility of incorporating more fuel economy improvements that are not engine related and thus improve the fuel economy performance over that available today.

For Volvo the available data on fuel economy are much more limited, since no 1980 certification fuel economy label data yet exists for their 2.4*l* family. However, the certification data submitted by Volvo indicated that their Diesel engine-powered vehicles typically achieve between 26 and 30 MPG and it is concluded that the changes necessary to achieve the 1.5 NO_x level need not reduce the fuel economy below 22 or 24 MPG.

Fleet Sales Weighted Average Fuel Economy Effects

Analysis by the Department of Transportation (DOT) indicates that there will be no necessity for Diesel powered vehicles in the manufacturers vehicle fleets in order to achieve the Corporate Average Fuel Economy goals for model years 1981 through 1984 (18 at ES–6). If the manufacturers have a problem with meeting the MPG standards, a procedure exists under EPCA to ask for reduction in fuel economy standards due to emission standards (17 at Section 502(d)(3), 15 U.S.C. 2002(i)). Therefore, there is no difficulty if the MPG analysis is in error or conservative, since an avenue of relief exists at DOT.

NO_x Emissions and Total Particulate Emissions

At various NO_x levels the Total Particulate (TP) emissions of Diesel engines is a subject of some interest. The applicants stressed that TP emissions were of concern to them because of EPA's pending TP rulemaking and questioned their capability to comply with 1.0 NO_x and

the proposed TP regulations simultaneously.

However, relatively little TP data was submitted by the applicants, and in most cases the data that were submitted were not measured from the same vehicles that EPA has used to make pass/fail determinations for NO_x.

In addition, TP data were not available for about half of the predicted technological improvements utilized by EPA in its pass/fail methodology. This lack of data introduces some uncertainty in estimating what might happen to TP emissions as NO_x is reduced. For example, TP data are unavailable for the GM timing factor based on VIN 99324, the DB Bosch EGR factor, and the DB water injection factor.

The above data, coupled with the lack of data on the other technical improvements, as stated above, introduce some uncertainty into estimating what the TP emissions will be. However, it should be pointed out that the assumption to make that would be the most conservative (in terms of being potentially least harmful to the applicants) would be to assume that lowered NO_x levels put upward pressure on TP emissions.

Post-Waiver Issues

As discussed in the waiver guidelines, the Administrator may make a grant or denial decision that is applicable for a period of time up to the maximum of four years allowed by the Act. This raises the issue of what could happen at the end of the waiver period and beyond. The Act treats this issue in Section 202(b)(6)(B)(iii):

> (iii) that the technology has a potential for long-term air quality benefit and has the potential to meet or exceed the average fuel economy standard applicable under the Energy Policy and Conservation Act at the expiration of the waiver.

Two post-waiver *potentials*, therefore, need to be discussed.

Long-Term Air Quality Benefit

Two considerations are germane to long-term air quality benefit, mileage effects and emission level potential. A technology would be considered to have long-term air quality benefit if the emissions at high mileage were relatively low and stable (no abrupt changes with mileage). At least two sources of information would support this potential for Diesels. First, EPA has tested several Diesel-powered vehicles in its emission factor program (Data are in the reports EPA–460/3–77–005 and EPA–460/3078–001 (a) and (b)). This data indicates low emissions compared to comparable gasoline-fueled vehicles at high mileage (some vehicles had more than 200,000 miles on them), and that the pattern shows no abrupt changes with mileage. Second, VW has recently certified a Diesel vehicle for California using California's optional 100,000 mile compliance procedure.

Therefore, in terms of high mileage emissions it can be said that Diesels have a potential for long-term air quality benefit.

The second consideration is whether or not Diesels have potential for low emission performance, especially for NO_x. Even a cursory look at the data in this document would lead to the conclusion that the potential for low NO_x exists. For example the low mileage data in Table V–9 which show NO_x values less than the 0.41 NO_x Research Goal. This performance is much better than the 1.0 NO_x level which is the subject of the waiver. Therefore, it can be concluded that on the basis of emission level, the Diesel also has a potential for long-term air quality benefit.

Fuel Economy Potential

Since it is EPA's technical judgment that fuel economy potential is the overwhelming reason for any manufacturer to investigate Diesel engine technology, the issues of fuel economy tends toward being technically obvious. One way in which the issue of fuel economy *potential* can be evaluated is to look at current technology and compare the composite fuel economy results to the most stringent sales weighted fuel economy standard now applicable, 27.5 MPG for 1985. If current technology vehicles are close to, meet, or they exceed this level the fuel economy potential is obvious.

Considering the MY 1980 data listed above, it is concluded that Diesel engine technology has potential to meet or exceed the average fuel economy standard applicable at the end of the waiver. For some engine/vehicle combinations (e.g. VW) the current 40+ MPG levels certainly indicate fuel economy potential. For the other manufacturers (GM, DB, Volvo) the current minimum MPG levels are 24 MPG and considering the lead time available, the potential for incorporating fuel economy improvements via engine technology and body redesign certainly exists, even at lower NO_x levels.

VIII. References

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2. Statement of General Motors Corporation at the EPA Hearing Regarding Waiver of Diesel NO_x Emission Standard, presented by Dr. Betsy Ancker-Johnson, Vice President Environmental Activities Staff, General Motors Corporation, Washington, D.C., June 19, 1979.

3. Transcript of Proceedings, Environmental Protection Agency, In the Matter of NO_x Diesel Waiver Hearings, Vol. 2, Washington, D.C., June 19, 1979. Acme Reporting Company.

4. GM submission for the record dated July 18, 1979 from Mr. T. M. Fisher (GM) to Mr. B. R. Jackson, Deputy Assistant Administrator MSED.

5. Statement of Daimler-Benz AG before the Environmental Protection Agency, Washington, D.C., June, 1979 Vol. 1.

6. Daimler-Benz Supplemental Information for the Record July, 1979 from Mr. Jerome N. Sonosky to Mr. B. R. Jackson.

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9. MSED, SEA and Manufacturers Audit Data Analysis, January, 1979.

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12. Application for Waiver of the 1981–1984 NO_x Emission Standards for light duty engines submitted to the Environmental Protection Agency by Volkswagen AG, May, 1979.

13. Transcript of Proceedings, Environmental Protection Agency, Waiver of 1981–1984 Model Year Light Duty Diesel NO_x Emission Standard, Volkswagenwerk AG of Germany, Volkswagen of America, Inc. Public Hearing, Washington, D.C., June 29, 1979. Acme Reporting Company.

14. Transcript of Proceedings, Environmental Protection Agency, Waiver of 1981–1984 Model Light Duty Diesel NO_x Emission Standard, Public Hearing, Automobiles Peugeot, Washington, D.C. June 20, 1979, Acme Reporting Company.

15. Transcript of Proceedings, Environmental Protection Agency, Waiver of Diesel NO_x Emission Standards, Public Hearing, Volvo, Washington, D.C. June 21, 1979. Acme Reporting Company.

16. Hand Delivered Letter from Mr. Jerome N. Sonosky to Mr. Benjamin R. Jackson, Deputy Assistant Administrator for Mobile Source and Noise Enforcement, dated July 3, 1979, subject "Waiver Applications for Possible Future Models."

17. Energy Policy and Conservation Act, Public Law 94–163, 42 USC 6201, December 22, 1975.

18. Rulemaking Support Paper Concerning The 1981–1984 Passenger Auto Average Fuel Economy Standards: DOT–NHTSA, July 1977, DOT HS 803 184.

19. California Exhaust Emission Standards and Test Procedures for 1981 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, State of California Air Resources Board, as amended, May 22, 1979.

Appendix B—Air Quality Summary

I. Introduction

Section 202(a)(b)(B) of the Clean Air Act states:

"Upon the petition of any manufacturer, the Administrator, after notice and opportunity for public hearing, may waive the standard required under subparagraph (B) of paragraph (1) to not to exceed 1.5 grams of oxides of nitrogen per vehicle mile for any class or category of light-duty vehicles and engines manufactured by such manufacturer during the four model year period beginning with the model year 1981 if the manufacturer can show that such waiver is necessary to permit the use of diesel engine technology in such class or category of vehicles or engines. Such waiver may be granted if the Administrator determines—

(i) That such waiver will not endanger public health,

(ii) That such waiver will result in significant fuel savings at least equal to the fuel economy standard applicable in each year under the Energy Policy and Conservation Act, and

(iii) That the technology has a potential for long-term air quality benefit and has the potential to meet or exceed the average fuel economy standard applicable under the Energy Policy and Conservation Act at the expiration of the waiver.

This appendix deals only with subsection 202(b)(6)(B)(i) of the Act, which deals with the air quality and public health considerations in granting or denying a waiver application.

II. NO_x Impacts

The primary focus of any decision under 206(b)(6)(B) involves the grant or denial of a waiver for NO_x emissions for classes of Diesel-powered vehicles, and therefore, the impact of any NO_x waivers is the primary focus of this study.

The most appropriate measure of the impact of granting/not granting a NO_x waiver for classes of Diesels is the projected ambient levels of NO_2.

NO_2 is a pollutant for which there is a National Ambient Air Quality Standard (NAAQS). Therefore, by comparing projected NO_2 levels to the NAAQS for NO_2 (0.05 ppm, annual arithmetic mean), the impact of granting/not granting a waiver can be estimated.

The impact on public health can also be inferred by comparing projected NO_2 levels to the NAAQS for NO_2 since the NAAQS level is that level which has been determined by EPA to be protective of public health.

This analysis also includes some projections of short-term NO_2 levels. These projections were made primarily as a sensitivity study of the potential localized impact of granting/not granting a waiver. EPA has short-term NO_2 under study in another forum i.e., section 10(c) of the Clean Air Act, and the analysis reported here is only one small consideration in that effort, and is not a basis at this time for the granting/not granting of a NO_x waiver.

In addition, short-term NO_2 is only one of the issues that EPA has under study at this time under Section 108(c) of the Clean Air Act. Since the evaluation of the health impact of nitrogen oxides and their derivatives or potential derivatives is now underway under Section 108(2), this document does not treat the subject of public health impacts of oxides of nitrogen and derivatives thereof directly. That analysis is properly included in the deliberations involved in the NAAQS process. A reference for these health implications for the interested reader is the External Review Draft of *Air Quality Criteria for Oxides of Nitrogen*, EPA Office of Reseach and Development, Environmental Criteria and Assessment Office, U.S. EPA Research Triangle Park, NC, 27711, June 1979.

Therefore the NO_x impact is seen to be properly limited to a study of the potential impact of granting/not granting a NO_x waiver on NO_2 levels.

IIA. Air Quality Impact

Effect of Waiver on Yearly NO_2 Levels

EPA performed a study ("Air Quality Analysis of Waiving the NO_x Standards for Light-Duty Diesel Vehicles," prepared by Air Management Technology Branch, Monitoring and Data Analysis Division, OAQPS, EPA RTP, N.C., February, 1979) of the impact of a LD Diesel NO_x waiver, were one to be granted, on yearly NO_x levels. The results showed little effect due to the granting of a waiver which may have been anticipated because of the relatively small number of vehicles affected by the waiver and the short period of time over which it would be applicable.

The basic approach was to compute the percentage change in air quality levels, under several combinations of scenarios and conditions, in twelve metropolitan areas and then average and present those percentage changes. The relative difference in the average percentage change for alternative strategies was used as the basis for strategy evaluation and comparisions.

The areas used were Phoeniz—Tucson, New York—New Jersey—Connecticut, Philadelphia, National Capital, Chicago, Cincinnati, Kansas City, Boston, Saginaw (Michigan), Detroit, Buffalo and Cleveland. This selection of metropolitan areas excluded California and high altitude areas, to which the waiver would not apply.

The percentage change air quality projections were made using the Linear Rollback model, which assumes that there is a proportional relationship between the rate of emission of the pollutant and its concentration in the atmosphere. It further assumes that the ratio between emitted NO_x and ambient NO_2 is fixed and that it will not change from year to year as NO_x concentrations change. The highest annual mean NO_2 concentration for the period 1974 through 1976 was selected as the base year design value for the analysis of the impacts on annual NO_2 levels.

The MOBILE 1 mobile source emission factor program was used to provide the composite emission factors for light-duty trucks, heavy-duty gasoline and heavy-duty Diesel vehicles. These emission factors remained constant over the scenarios analyzed. A computer program was developed to provide estimates of the LDV composite emission factor for the various Diesel scenarios.

The following assumptions formed the scenarios analyzed by this analysis:

1. Possible 1981–1984 model year NO_x standards for Diesel powered LDV's of 0.4, 1.0 and 1.5 grams/mile. After model year 1984, the NO_x standard is assumed to be held constant for the 0.4 gram/mile standard, whereas, for the other two cases, the appropriate standard is 1.0 grams/mile.

2. Market penetration of Diesel engines in LDV's is assumed to increase at a linear rate beginning with a two percent (2%) market share in 1978. Three maximum market shares of 10%, 25% and 50% in 1985 are examined. Following model year 1985, the market shares are assumed to remain constant at the 1985 level.

3. Two different deterioration rates for Diesel-powered LDV's are considered; the midpoint and maximum deterioration rates from the range of possible deterioration rates provided for the analysis.

The results of the analysis are summarized in Table 1. The analysis showed that for future years there are generally decreasing levels of NO_2 due to the effect of NO_x controls. Therefore, any effect that the Diesel NO_x waiver would have would be to slow this decrease.

Table 1.—*Average Percent Reductions in Annual Average Nitrogen Dioxide Design Values*

[Linear rollback, 0.004 ppm background]

Strategy			Projection year						
LD diesel market penetration	Waiver	Deterioration rate	1978	1981	1982	1983	1984	1985	1986
Percent:									
10	No	High	1	2	[illegible]	[illegible]	[illegible]	3	[illegible]
10	Full	High	1	1	3	[illegible]	3	[illegible]	6
25	No	High	1	1	3	[illegible]	[illegible]	3	6
25	Full	High	1	1	2	2	2	1	4
50	No	High	1	1	2	[illegible]	2	[illegible]	4
50	Full	High	1	1	2	1	1	0	2
10	No	Medium	1	2	[illegible]	3	3	[illegible]	7
10	Full	Medium	1	2	3	3	[illegible]	3	7
25	No	Medium	1	2	[illegible]	3	3	3	7
25	Full	Medium	1	[illegible]	3	3	[illegible]	[illegible]	6
[illegible]	No	Medium	1	2	3	3	[illegible]	[illegible]	7
50	Full	Medium	1	1	2	[illegible]	[illegible]	1	5

NOTE.—Values are rounded to the nearest whole percentage point, i.e. 2.5% becomes 3% and 2.4% becomes 2%.

In general, the EPA analysis showed that there was no slower progress in reducing NO_2 concentrations under the waiver case compared to the no waiver case. The only possible exception to this is when a non-neglegible NO_x deterioration rate is assumed for light duty Diesels. The results indicate that only the scenarios for the 1.5 g/mi standard (a waiver granted) with (1) mid-range to high NO_x deterioration rates, and (2) accompanying market shares of 25 and 50 percent, respectively, showed measurably slower progress in NO_2 reductions (by 1 to 2 percent) relative to 1.0 g/mi (a waiver denial level). At lower Diesel market shares, there is virtually no change in NO_2 reduction progress, even at the higher deterioration rates (there is a 1% reduction in 1985 only, at the high deterioration rate). The best estimate for market share in 1985 is 11.4% and therefore it can be concluded that even if high deterioration rates are applicable to in-use light duty Diesels, then there still are no projected significant changes in annual average NO_2 levels with a waiver-grant assumption.

In the GM Diesel NO_x waiver submission, the annual ambient air quality impact was computed assuming a "worse case" condition of (1) NO_x levels at the end of MY84 (the expected peak), (2) maximum waiver of 1.5 g/mi NO_x, and (3) waiver granted for 4 years. They assumed a total LD Diesel sales penetration of 4.7% for MY81, 7.5% for MY82, 8.9% for MY83 and 9.5% for MY84. They also assumed 1.5 g/mi NO_x (20% of which is assumed to be NO_2) for the waiver vehicles and 1.0 g/mi NO_x (10% of which is assumed to be NO_2) for the non-waiver case. They concluded that the total change in annual regional NO_x and NO_2 concentrations would be no more than 0.5% in late 1984. The model used is not described and therefore cannot be evaluated. No discussion was given by GM of deterioration rates.

The Daimler-Benz submission deals with longer term regional impact with virtually the same assumptions. They conclude that changes in predicted emissions with the NO_x waiver would be less than 0.3%. No consideration was given to deterioration. The model was that used during the analysis of short-term NO_2 and O_3 standard for EPA by EEA. (EEA is the contractor that prepared the air quality portions of both the Daimler-Benz and Volkswagen submission.)

As observed above, Volkswagen used the same contractor as Daimler-Benz for their air quality analysis. As such, the air quality portions are very similar. Volkswagen concludes that granting the waiver will result in a "very small" increase in regional NO_x levels.

The Volvo air quality analysis was much more simplistic wherein they considered the difference between a full waiver and no waiver NO_x (1.5 g/mi and 1.0 g/mi) and multiplied it times expected miles traveled in the New York City area. The New York City area was chosen to represent the area that would be subjected to the greatest amount of excess emissions. The basic conclusion was that granting a waiver for Volvo Diesel vehicles would result in 28.1 extra tons NO_x per year being emitted in New York City in 1984 (the peak year). This is considered by Volvo to be insignificant when compared to "all existing criteria" including the 50 ton/year limitation set for individual point sources locating in areas not meeting National Ambient Air Quality Standards. This Volvo analysis is clearly simplistic and impossible to compare with other analyses. The Peugeot submission contains no significant air quality information. Therefore, a summary of the industry analysis of annual ambient air quality impact due to "worse case" assumptions would be an increase in NO_x of 0.5% or less.

Short Term Regional NO_2 Levels

EPA computed short term (second maximum hourly) NO_2 impacts on air quality in the same manner as the computation for annual impact. The above discussion of models, assumptions and scenarios applies, also, to the short term regional impact computation. The results (see Table 2) show that there are generally decreasing levels of short term NO_2 in each of the years through 1990. This tend is slowed by a difference of no more than one percent for a (1) the case of up to a 50% LD Diesel introduction rate and low to medium deterioration rate, and (2) the case of up to 25% introduction rate for the high deterioration rate. If there were to be a 50% introduction rate for LD Diesels and a high deterioration rate, the tend toward lower NO_2 levels would be slowed by a difference of 2% in several years. However, as observed above, EPA best estimates of LCD Diesel introduction rates are less than 25% and, therefore, even if the NO_x levels from LD Diesels deteriorate rapidly (which has not been observed), the impact on the downward tend of short term regional NO_2 levels would be 1 percent or less.

GM reported on some computations that they made on short term (1 hour) regional NO_2 impacts of the NO_x waiver. They concluded that under the "worse case" conditions used as a computation base, that total short term regional change in NO_2 concentrations should not exceed 0.5% in late 1984 (the date of estimated maximum impact). The analyses was based on the assumption that light duty Diesels would account for 5% of the LDVMT in 1984 and also considered other NO_x sources.

Short-Term, Roadside NO_2 Exposure Levels

EPA performed another air quality study (Cole, Henry S., "The Impact of an NO_x Diesel Waiver on NO_2 Concentrations Downwind of a Major Line Source," Source Receptor Analysis Branch, OAOPS, EPA, RTP, N.C., May, 1979) wherein the principal question examined was whether an NO_x waiver for LD Diesels will cause an appreciable increase in short-term NO_2 concentration immediately downwind of roadways. The basic approach was to model a downwind site adjacent to the San Diego Freeway in Los Angeles, California. The computation was done using some actual measured data we well as scenario assumptions. The method was not computerized.

In the case of 1982 waiver/no waiver comparison (which uses a 3% market penetration) and a 0.5 NO_2/NO_x ratio, there is no change in NO_2 levels under one computation and less than a 5% increase under another. The report concludes that the somewhat small influence of a LD Diesel waiver is due to (1) the impact of LD Diesels is small relative to that of other vehicles, and (2) the NO_x concentrations downwind of major freeways are likely to be high enough such that ozone and not NO_x is the factor which limits the formation of NO_2.

The Daimler-Benz submission analyses (and also the the Volkswagen analyses because Volkswagen also contracted with EEA) studied short term (peak one-hour) roadside NO_2 exposure levels. They used the Highway model and applied it to the Los Angeles Catalyst Study site. They used traffic assumptions that were chosen to simulate "worse-case" conditions. A perpendicular wind field and neutral atmospheric stability conditions were also assumed. The conclusion drawn by Daimler-Benz is that granting a NO_x waiver for all Diesels for all four years is likely to raise peak one-hour NO_2 levels near a high volume highway by no more than 10 mg/m^3.

This can be compared to the most stringent hourly standard being considered by EPA (according to VW, Daimler-Benz and their contractor, EEA) for future implementation—235 mg/m^3. A more probable standard (again, according to VW and Mercedes Benz and their contractor, EEA) would be approximately 470 mg/m^3.

The General Motors analysis concluded that one hour maximum roadside NO_2 exposures from light duty vehicles only could increase by 6.5 $\mu g/m^3$. This represents a 7.9% increase in NO_2 levels and is arrived at by assuming a maximum waiver (1.5 g/mi) for the maximum length of time (1981–84), the "highest possible rate of light-duty Diesel sales", and that the waiver would be granted for all manufacturers in all classes of light-duty Diesels.

Table 2.—*Average Percent Reductions in Second Maximum Nitrogen Dioxide Hourly Design Values*

[Linear rollback, 0.004 ppm background]

Strategy			Projection year						
LD diesel market penetration	Waiver	Deterioration rate	1978	1981	1982	1983	1984	1985	1990
Percent:									
10	No	High	2	2	3	3	3	3	7
10	Full	High	2	1	3	3	3	3	6
25	No	High	2	1	3	3	3	3	6
25	Full	High	2	1	2	2	2	2	5
50	No	High	2	1	2	3	2	2	5
50	Full	High	2	1	2	1	1	0	2
10	No	Medium	2	2	3	3	4	4	7
10	Full	Medium	2	2	3	3	3	3	7
25	No	Medium	2	2	3	3	4	3	7
25	Full	Medium	2	2	3	3	3	3	7
50	No	Medium	2	2	3	3	3	3	7
50	Full	Medium	2	1	3	2	2	2	6

NOTE.—Values are rounded to the nearest whole percentage point, i.e. 2.5% becomes 3% and 2.4% becomes 2%.

II.B Summary–NO_2 Impacts

The EPA, the industry, and the industry-sponsored studies are all in general agreement that the effect of a NO_x waiver will:

1. Tend to slow trends towards decreasing ambient NO_2 levels or slightly increase ambient NO_2 levels, but,

2. Any change will be small in (a) absolute value or (b) as a percent of ambient levels.

Therefore, it can be concluded that even a four-year waiver for all Diesels would have only a limited impact on arithmetic annual average NO_2 levels.

In order to investigate the sensitivity to the four-year assumption, the analysis was repeated assuming that the waiver would be granted for 2 years. The results are shown below in Tables 3 and 4.

The two-year scenario results, as expected, show even less of an NO_2 impact. In fact, given the definition in the PSD regulations, the impact is less than significant (44 FR 51924, September 5, 1979). Thus for a two-year waiver it can be concluded that the change in NO_2 levels will be of such a magnitude that the public health will not be endangered.

Table 3.—*Average Percent Reductions in Annual Average Nitrogen Dioxide Design Values; Full Waiver Assumed To Be 1.5 g/mi for 1981 and 1982 Only*

[Linear rollback, 0.004 ppm background]

Strategy			Projection years							
LD diesel market penetration	Waiver	Deterioration rate	1978	1981	1982	1983	1984	1985	1987	1990
Percent:										
10	No	High	1	2	3	3	3	3	(1)	6
10	Full	High	1	2	3	3	3	3	5	6
25	No	High	1	1	3	3	3	3	(1)	6
25	Full	High	1	2	2	3	2	2	4	5
50	No	High	1	1	2	2	2	2	(1)	4
50	Full	High	1	1	2	2	2	1	3	4
10	No	Medium	1	2	3	3	3	3	(1)	7
10	Full	Medium	1	2	3	3	3	3	5	7
25	No	Medium	1	2	3	3	3	3	(1)	7
25	Full	Medium	1	2	3	3	3	3	5	7
50	No	Medium	1	2	3	3	3	3	(1)	7
50	Full	Medium	1	2	3	3	3	3	5	6

[1] Projection not computed.

NOTE.—Values are rounded to the nearest whole percentage point, i.e., 2.5% becomes 3% and 2.4% becomes 2%.

Table 4.—*Average Percent Reductions in Second Maximum Hourly Design Values; Full Waiver Assumed To Be 1.5 g/mi for 1981 and 1982 Only*

[Linear rollback, 0.004 ppm background]

Strategy			Projection years							
LD diesel market penetration	Waiver	Deterioration rate	1978	1981	1982	1983	1984	1985	1987	1990
Percent:										
10	No	High	2	2	3	3	3	3	(1)	7
10	Full	High	2	2	3	3	3	3	5	7
25	No	High	2	1	3	3	3	3	(1)	6
25	Full	High	2	2	3	3	3	2	4	6
50	No	High	2	1	2	3	2	2	(1)	5
50	Full	High	2	1	2	2	2	1	3	4
10	No	Medium	2	2	3	3	4	3	(1)	7
10	Full	Medium	2	2	3	4	4	4	6	7
25	No	Medium	2	2	3	3	4	3	(1)	7
25	Full	Medium	2	2	3	3	3	3	5	7
50	No	Medium	2	2	3	3	3	3	(1)	7
50	Full	Medium	2	2	3	3	3	3	5	7

[1] Projection not computed.

NOTE.—Values are rounded to the nearest whole percentage point, i.e., 2.5% becomes 3% and 2.45 becomes 2%.

II.C Effect of Waiver on Oxidant Levels

The principal air quality issue that is being considered relative to the NO_x waiver issue is the impact that granting such a waiver would have on ambient NO_2 levels. However, since NO_x compounds are precursors to oxidant (ozone) formation, EPA performed an analysis of the impact of a NO_x waiver on area wide (yearly and short-term) ozone levels. The senarios studied included (1) a no-Diesels base case, (2) 10%, 25% and 50% LD Diesel market penetrations, (3) low, medium and high NO_x deterioration rates for LD Diesels, and (4) waiver and no waiver cases. The overall conclusion reached was that all Diesel senarios studied showed no significant differences in ozone levels as a result of a NO_x waiver grant. The manufacturers submissions reached generally the same conclusion.

III. Other Pollutants and Other Concerns

Although the limited nature of Section 202(b)(6)(B) could be considered as constraining the analysis to only NO_x, it is appropriate to consider other areas.

A precedent exists for consideration of other pollutants (not just HC, CO, or NO_x). The precedent is the administrator's decision on the applications for suspension of the (then) 1977 standards. This decision relied heavily on EPA's concern about the potential increases in the emissions of sulfuric acid mist from vehicles that could meet the standards then required for model year 1977.

The record for the Diesel NO_x waiver requests was examined to see if there were data or discussions or issues that involved unregulated emissions. Three areas were identified; Diesel particulate emissions, other unregulated emissions and the Diesel cancer issue.

III. A. Particulate Emissions

Particulate emissions were discussed at length at the public hearing, but the discussions of particulate emissions primarily centered around the relationship(s) between NO_x and particulate emissions from the engine, and how (if) that influenced NO_x control capability.

There was some discussion of the particulate impact of granting/not granting a waiver. For example, the GM 19 June, 1979 Transcript at page 6 (19 June TR @6), GM said "until we have a better understanding of the health effects of diesel particulates, increasing them for the sake of lower NO_x would not appear to be in the public interest".

GM also discussed their air quality models for particulate (19 June TR @247–261). GM made some predictions of total particulate (TP) air quality with and without a waiver. Interestingly, GM did not assume that without a waiver there would be no Diesels. Instead, their no-waiver case assumed that the no-waiver Diesels would emit 1.0 grams per mile TP and that the waiver case Diesels would emit 0.6 grams per mile TP, (19 June TR @249). Other manufacturers (VW and Daimler-Benz) also assumed that there would be Diesels, even in a no waiver case.

However, none of the applicants indicated that the increased levels of particulates in the ambient air resulting from a no-waiver scenario would represent an unreasonable risk under Section 202(b)(6)(B) of the Act. Therefore, the Diesel particulate/health impact relationship is somewhat a diffuse issue for these NO_x waiver proceedings.

Another Diesel particulate related issue that must be mentioned here was also discussed at the Hearings. That issue is EPA's proposed total particulate standards for light-duty Diesels. In response to Section 202(a)(3)(A)(iii) of the 1977 Clean Air Act, EPA proposed emission standards for total particulates from light-duty Diesels (**Federal Register**, Vol. 44, No. 23, Thursday, February 1, 1979 Part IV). That rulemaking is now being finalized within the Agency.

It might be considered that this document would discuss the health effects of particulate emissions, TP/NO_x relationships from an air quality point of view, cost/effectiveness of the proposed regulations, comparison to other sources of TP emissions etc., etc. However, all of the above issues and more have been (1) considered by the Agency before the TP standards were proposed (2) considered at the Public Hearings held on the subject, and in the comments to the Proposed Rule, and (3) are now being considered by the Agency in its study of the Final Rule. Therefore this document will not treat these issues further.

Summary-Total Particulate Impact

To the extent that waivers of the 1.0 NO_x standard are denied, there may be some upward trend in total particulate levels in the ambient air. Conversely, to the extent that waivers of the 1.0 NO_x standard are granted there may be some lesser degree of impact.

III.B. Other Unregulated Emissions

The waiver request guidelines also asked for vehicle and health impact data comparing the LD Diesel waiver and no-waiver case on emissions such as nitrosamines, aldehydes, phenols, B(a)P, gaseous organics, organics extracted from particulates and sulfates. Very little data was submitted, which precludes a rigorous analysis of the affects of a waiver grant or denial.

The GM submission concluded that, based on their experimental data, the waiver grant case would result in unregulated pollutant emission levels (excluding NO_2) equal to or lower than those levels that would result from not granting a waiver. This data came primarily from a single vehicle, the GM experimental 5.7 liter Diesel. Since this is an experimental engine, it does not directly relate to the 5.7 liter family for which a waiver is sought and is even less related to other engine families. Therefore, it is not possible to directly relate the small amount of unregulated emissions information provided to the issue of a NO_x waiver.

In both the Daimler-Benz and Volkswagen submissions, very little vehicle specific unregulated emissions data is given that would permit an analysis of the influence of a NO_x waiver on Volkswagen or Daimler-Benz engine families. These manufacturers did submit a limited air quality analysis, but the input for the analysis was generalized emission factors instead of engine—specific data. The other waiver applications (Volvo and Peugeot) were even less detailed in the non-regulated emissions area.

Therefore, because of the inconclusive data presented, it can not be used to support either a waiver grant or denial.

III.C. The Diesel Cancer Issue

The subject of the Diesel cancer issue was discussed more directly by GM. The record (19 June TR @237–247 and again @261–263) shows that the discussion centered on the London Transport Worker's Study (LTWS), what some of the pros and cons of that study are and what can or cannot be learned from it.

GM discussed some of the limitations (19 June TR @237, 240, 241, 243), but concludes (19 June TR @244) that the results were negative even though subsequently (19 June TR @245) they modified their position somewhat by indicating that further study was needed.

Others (19 June TR @245) have indicated that the usefulness of the LTWS is questionable, and there is also certainly not agreement on the usefulness of the LTWS, even among the applicants. For example, Daimler-Benz in their application discussed in the 18 June TR @176 discussed problems with the LTWS, and Daimler-Benz indicated in a *specific* response to a specific question that they were unaware of a good study in the epidemiology area (18 June TR @179). VW also pointed that a good study was "missing" (20 June TR @135).

Based on the record of the Diesel NO_x waiver hearings, EPA concludes that there are enough problems with the LTWS to make it difficult to drawn universally acceptable and meaningful conclusions from it. This study was discussed at a symposium on diesels.[1] The London researcher concluded that there are sufficient difficulties with the current data base which do not permit any meaningful conclusions to be drawn at this time.

Other issues in this area discussed at the hearings were planned or on-going work e.g., (20 June TR @110, 115, 118, 123, 132, 133, (VW); 20 June TR @21–42, (Peugeot), etc. from which none of the applicants would draw conclusions.

[FR Doc. 80-1857 Filed 1-22-80; 8:45 am]

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[1] "Trends to Lung Cancer Incidence in London in Relation to Diesel Fume Exposure". International Symposium on Health Effects of Diesel Engine Emissions, Session VIII. December 3, 1979.

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 86

[FRL 1381-4]

Revised Motor Vehicle Exhaust Emission Standards for Oxides of Nitrogen (NO_x) for 1981 and 1982 Model Year Light-Duty Vehicles

AGENCY: Environmental Protection Agency.

ACTION: Final rule.

SUMMARY: This regulation establishes NO_x emission standards for 1981 and 1982 model year light-duty vehicles belonging to certain diesel engine families for which I have granted waivers from the standard otherwise applicable under section 202(b)(6)(B) of the Clean Air Act, 42 U.S.C. 7521(b)(6)(B).

EFFECTIVE DATE: February 22, 1980.

ADDRESS: Information relevant to this rule is contained in Public Docket EN-79-3 at the Central Docket Section of the Environmental Protection Agency (EPA), Room 2903B, 401 M Street, SW., Washington, D.C. 20460 and are available for review between the hours of 8:00 a.m. and 4:00 p.m. As provided in 40 CFR Part 2, a reasonable fee may be charged for copying services.

FOR FURTHER INFORMATION CONTACT: Maureen Smith, Office of Mobile Source Air Pollution Control (ANR-455), or Paul Stern, Manufacturers Operations Division (EN-340), U.S. Environmental Protection Agency, 401 M Street, SW., Washington, D.C. 20460, (202) 426-2514 or 472-9421.

SUPPLEMENTARY INFORMATION: Section 202(b)(1)(B) of the Clean Air Act ("the Act"), 42 U.S.C. 7521(b)(1)(B), requires that regulations applicable to NO_x emissions from light-duty vehicles or engines manufactured during or after the 1981 model year shall contain standards which provide that such emissions from vehicles or engines shall not exceed 1.0 gram per vehicle mile. Regulations implementing this requirement have established this NO_x standard.

Section 202(b)(6)(B) of the Act authorizes the Administrator, upon application by any manufacturer, to waive the statutory NO_x standard for the 1981 through 1984 model years for any light-duty diesel engine family for which the Administrator can make the required statutory findings. I must promulgate interim NO_x standards for those model years for which waivers are granted, applicable to the subject light-duty diesel engine families. Applications for these waivers were submitted by General Motors Corporation, Daimler-Benz AG, Volkswagen AG, AB Volvo, and Automobiles Peugeot. The statutory criteria, my determinations with respect to the vehicle models covered by the waiver applications, and my decision to grant or deny the waiver applications appear in the consolidated decision published above. In that decision, I granted waivers covering the following engine families for 1981 and 1982 model years only:

Manufacturer and Engine Family

General Motors Corporation, 5.7 liter.
Daimler-Benz AG, 2.4 liter. 3.0 liter naturally aspirated. 3.0 liter turbocharged.
AB Volvo, 2.4 liter naturally aspirated.

Having decided to grant waiver applications for these five diesel engine families, I am simultaneously promulgating regulations adopting emission standards not permitting NO_x emissions from 1981 and 1982 model year vehicles of these five engine families to exceed the prescribed levels. The public has received an opportunity to comment on the waiver applications at issue, and I have considered those comments in making the consolidated decision which requires the promulgation of this rule. Also, the 1981 certification process is underway. For these reasons, I find that providing notice and an opportunity to comment on this rulemaking before final promulgation is impracticable and unnecessary.

Note.—The Environmental Protection Agency has determined that this action does not constitute a major proposal requiring preparation of a Regulatory Analysis under Executive Order 12044.

In addition, because the decision already accompanying this rulemaking contains a detailed analysis indicating that this rulemaking will have a negligible effect on air quality, the Environmental Protection Agency has not prepared an Environmental Impact Statement to accompany this rulemaking.

Dated: December 21, 1979.

Douglas M. Costle,
Administrator.

40 CFR Part 86 is amended as follows:

Subpart A—General Provisions for Emission Regulations for 1977 and Later Model Year New Light-Duty Vehicles, 1977 and Later Model Year New Light-duty Trucks and 1977 and Later Model Year New Heavy-Duty Engines

40 CFR 86.081-8(a)(1), published at 44 FR 69416 (December 3, 1979), is revised to read as follows:

§ 86.081-8 Emissions standards for 1981 and later model year light-duty vehicles.

(a)(1) Exhaust emissions from 1981 and later model year light-duty vehicles shall not exceed the following levels for the following pollutants:

(i) Hydrocarbons—0.41 grams per vehicles mile;

(ii) Carbon monoxide—3.4 grams per vehicle mile, except that

(A) Carbon monoxide emissions from light-duty vehicles of the following 1981 and 1982 model year engine families shall not exceed 7.0 grams per vehicle mile:

Manufacturer and Engine Family

American Motors Corporation, 258 CID.
BL Cars, Ltd., TR8. XJ12.
Chrysler Corporation, 1.7 liter. 3.7 liter. 5.2 liter/4-V.
General Motors Corporation, 2.8 liter/173 CID-2V. 3.8 liter/231 CID-2V.
Toyota Motor Company, Ltd., 88.6 CID.

(B) Carbon monoxide emissions from light-duty vehicles of the following 1981 model year engine families shall not exceed 7.0 grams per vehicle mile:

Manufacturer and Engine Family

Toyo Kogyo Company, Ltd., 91 CID. 120 CID.

(iii) Oxides of nitrogen—1.0 grams per vehicle mile, except that: (A) Oxides of nitrogen emissions from 1981 and 1982 model year light-duty vehicles manufactured by American Motors Corporation shall not exceed 2.0 grams per vehicle mile; (B) oxides of nitrogen emissions from light-duty vehicles of the following 1981 and 1982 model year engine families shall not exceed the prescribed levels:

Manufacturer	Engine family	Model year	NO_x (gpm)
General Motors Corp.	5.7 liter	1981, 1982	1.5
Daimler-Benz AG	2.4 liter	1981	1.5
		1982	1.25
	3.0 liter naturally aspirated.	1981, 1982	1.5
	3.0 liter turbocharged	1981, 1982	1.5
AB Volvo	2.4 liter naturally aspirated.	1981, 1982	1.5

(Secs. 202 and 301(a) of the Clean Air Act, as amended, 42 U.S.C. 7521, 7601(a) (Supp. I 1977))

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